California State Water Project

Volume VI
Project Supplements

Bulletin Number 200

November 1974

State of California
The Resources Agency
Department of Water Resources

State of California
THE RESOURCES AGENCY

Department of Water Resources

BULLETIN No. 200

CALIFORNIA STATE WATER PROJECT

Volume VI

Project Supplements

NOVEMBER 1974

NORMAN B. LIVERMORE, JR.
Secretary for Resources
The Resources Agency

RONALD REAGAN
Governor
State of California

JOHN R. TEERINK
Director
Department of Water Resources

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FOREWORD

This is the sixth and final volume of this bulletin which records aspects of the planning, financing, design, construction, and operation of the California State Water Project. The subjects of the other volumes are: Volume I, History, Planning, and Early Progress; Volume II, Conveyance Facilities; Volume III, Storage Facilities; Volume IV, Power and Pumping Facilities; and Volume V, Control Facilities.

The State Water Project conserves and distributes water to much of California's population and irrigated agriculture. It also provides electric power generation, flood control, water quality control, new recreational opportunities, and enhancement of sports fisheries and wildlife.

Construction of the first phase of the State Water Project was completed in 1973. The $2.3 billion reimbursable cost is being repaid by the water users and other beneficiaries. It is expected that another $0.7 billion will be spent during the next decade to construct authorized facilities for full operation.

This volume is quite broad in content since it is intended to cover those significant areas not discussed in the preceding five volumes. It describes corollary or peripheral activities that were required to make the State Water Project a complete operating entity

John R. Teerink

John R. Teerink, *Director*
Department of Water Resources
The Resources Agency
State of California

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DIVISION OF OPERATIONS AND MAINTENANCE

H. G. Dewey, Jr.	Division Engineer
James J. Doody	Deputy Division Engineer

State of California
Department of Water Resources

CALIFORNIA WATER COMMISSION

AUTHORS OF THIS VOLUME

Department of Water Resources

Thomas H. T. Morrow	Chief, Division of Land and Right of Way
Laurence B. James	Chief Engineering Geologist
Stephen E. Smith	Chief, Contract Administration
John H. Lawder	Construction Supervisor
Donald H. McKillop	Chief, Water Operations Branch
Vernon H. Persson	Chief, Structural and Architectural Unit, Civil Design Section
Herbert C. Hyde	Senior Engineer, Water Resources
George A. Lineer	Senior Engineer, Water Resources
Paul W. Morrison, Jr	Senior Seismologist
George C. Myron	Senior Engineer, Water Resources
Fleming E. Peek	Senior Engineer, Water Resources
James L. Zeller	Construction Supervisor
John W. Flynn	Associate Engineer, Water Resources
Paul Lew	Associate Engineer, Water Resources

Department of Parks and Recreation

Francis A. Riddell	Supervisor, Cultural Resources Section
William H. Olsen	State Park Archeologist
J. T. Ruckle	Archeological Specialist

EDITOR

Arthur C. Gooch	Chief, Program Analysis Office

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Kolden L. Zerneke

ABSTRACT

This volume describes those corollary activities required to make the State Water Project a complete operating entity.

Program Management Information Systems were developed in 1961 to meet the information and scheduling needs of the Department of Water Resources. Two principal systems were developed: Program Control System and Program Management Technique (PROMT). Through the use of these systems, the Department was aided in completing the State Water Project on time and within available funding.

Two major items critical to the timely completion of the State Water Project were the acquisition of rights of way and numerous relocations. About 4,900 parcels involving acquisition of fee and permanent or temporary easements were purchased at a total cost in excess of $121 million. Approximately 1,400 relocations required more than 900 separate agreements covering work with a total cost of about $160 million. Many of these relocations were major engineering projects in themselves.

Early in 1963, the Department established a policy of creating a unifying architectural motif to be used with all structures of the State Water Project. The motif emphasized simplicity in the functional and structural use of concrete, steel, masonry, and glass. The color scheme of the motif included the use of accent colors of turquoise and red in contrast with the predominant grays, blacks, and whites of the many structures of the Project.

Planning and building of the State Water Project was influenced by a variety of geology-related factors. Most of its structures were affected to some degree by their geologic environment. In addition to local studies on which to base the location of specific structures, broader scope programs were undertaken which influenced major decisions and policies concerning selection of routes for aqueducts and the location, design, and operation of major facilities.

Since Oroville Dam blocks the upstream migration of salmon and steelhead trout, it was necessary to construct a fish barrier dam and hatchery to ensure preservation of the species. About 20,000,000 eggs are taken annually and, subsequently, the hatched offspring are raised to the juvenile stage before being released into the river to migrate downstream to the Pacific Ocean.

The Delta Fish Protective Facility screens fish from water that is being pumped into the California Aqueduct. As many as 26,615,000 fish of several varieties have been trucked from this facility annually and released at the confluence of the Sacramento and San Joaquin Rivers.

Operation centers, subcenters, and maintenance stations are located throughout the Project. The basic guidelines for establishing the locations of these facilities were drawn from a study by the Department and consultants that concluded the building complexes should not be located more than 60 miles apart. The buildings were designed to be esthetically pleasing as well as functional and durable.

The Department maintains four visitor centers throughout the Project and may construct two more. In addition, special interest groups may arrange for guided tours through several of the Project's power plants.

Many sites of historic and prehistoric importance were uncovered and disturbed by the construction activities associated with the building of the State Water Project. Archeologists worked in advance of and during construction to carry out investigations and preserve artifacts. Investigations of ancient civilizations were made possible by use of Project Funds, and historical artifacts were preserved by either relocating them or placing them in temporary storage.

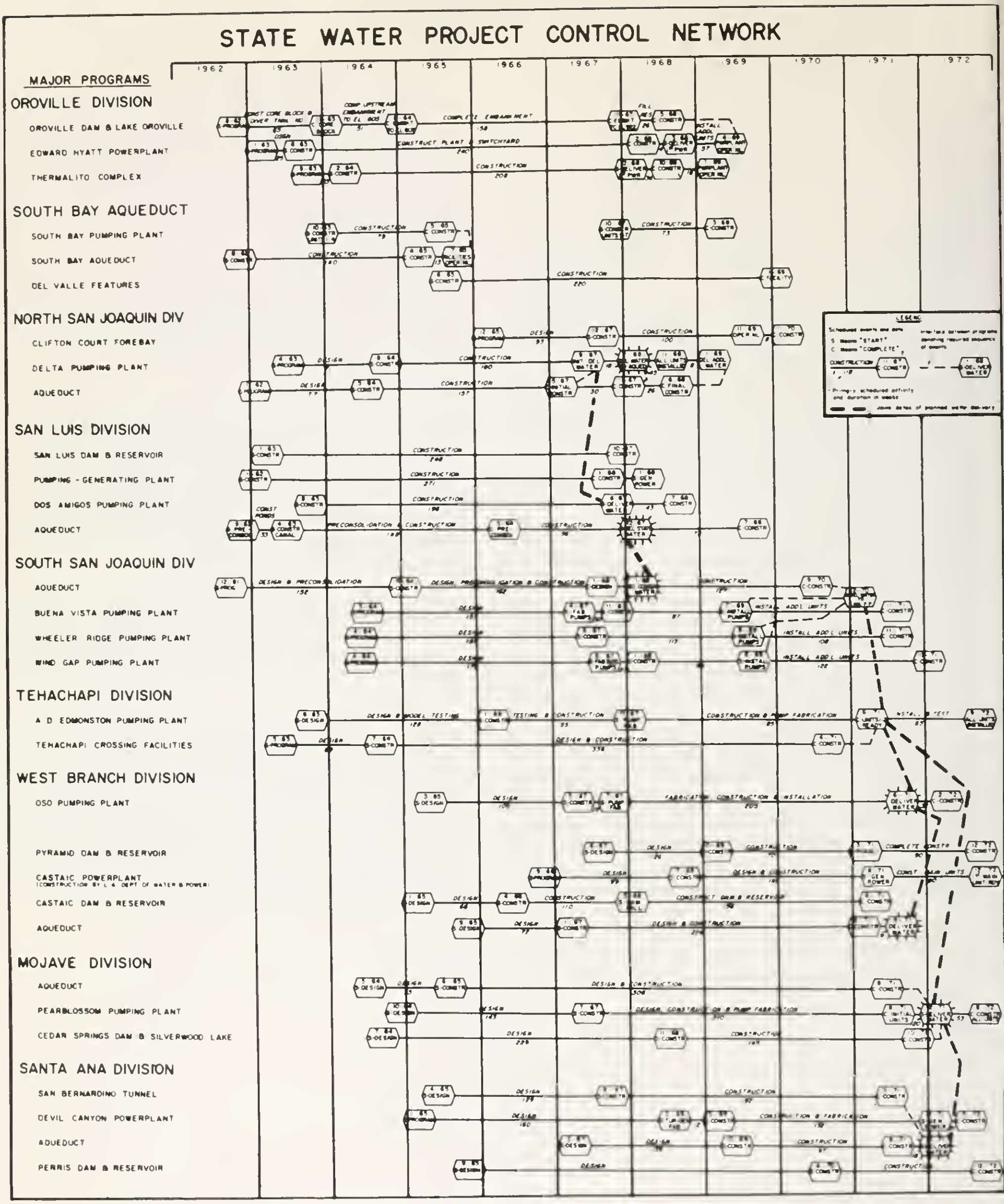


Figure 1. Summary of Project Schedule

CHAPTER I. PROJECT MANAGEMENT INFORMATION SYSTEMS

Construction of the initial facilities of the State Water Project involved the preparation of plans and specifications and the award and administration of some 450 contracts, with a total value of about $2.3 billion, in the period of about a decade. Individual contracts, ranging in value from a few thousand dollars to over $120 million, included civil works, mechanical and electrical equipment, and electronic control systems. A matter of considerable concern was the formidable task of scheduling and coordinating the hundreds of activities necessary to bring these contracts to timely completion and the Project to operational status in accordance with water delivery dates. A highly summarized version of the project schedule is depicted on Figure 1.

The control and coordination of such an unprecedented engineering program required the Department of Water Resources to develop and implement management information systems equal to the task. The principal systems developed for the State Water Project were the Program Control System and the Program Management Technique (PROMT).

Program Control System

The Program Control System was developed to provide a positive means to formulate, document, and implement the Department's programs to ensure that objectives were met in a timely, economical, and coordinated manner. Program as used herein consists of the design, right-of-way, and construction activities necessary for the completion of a major facility, such as a pumping plant or a major reach of aqueduct. The system provides a means to control activities and disseminate information on various segments of the programs to appropriate levels of the organization. It also provides a means to monitor and report actual progress with respect to planned progress.

The Department recognized the need to develop a formalized program control system for its programs even before the construction of the State Water Project began in earnest. Various elements of such a system came into use as construction gained momentum. The Department adopted a formalized program control system in July 1961 (Reference 1). While patterned after the system used by the U. S. Bureau of Reclamation and other federal agencies, substantial modifications were made to meet the specific needs of the Department.

The Program Control System integrates the processes of program formulation, budgeting, scheduling, work authorization, cost accounting, and management reporting. The major elements of the system are program estimates, control schedules, program statements, work authorities, management reports, and a cost classification system designed for electronic data processing.

Program Estimate

A program estimate reflects the total cost of elements of a program without regard to time. For construction of the State Water Project, this is in the form of a preliminary construction cost estimate, called a "basic estimate", and includes associated engineering costs usually determined as a percentage of estimated construction costs. These estimates are reviewed and updated at least annually.

Control Schedule

The control schedule provides a general plan for carrying out engineering programs based on program estimates spread over a period of time (Figure 2). Costs shown include construction contract costs as well as engineering and right-of-way costs. Costs shown as direct pay (DP) include the purchase of items or services outside the Department of Water Resources, such as payments to contractors, cost of relocations by utilities, and purchase of rights of way. State operations (SO) include salaries and wages of department personnel for services such as design, construction supervision, negotiations for utility relocations and purchase of rights of way, surveying, consultant fees, services by other state agencies, and management. When approved by the Director, the schedule constitutes the Department's official program and becomes the basis for the detailed annual budget. Control schedules are the source document for identifying inevitable changes and for obtaining approval for any deviations.

Control schedules are prepared annually by the line organizations responsible for carrying out the work. Initially, the schedules showed the cost on a fiscal year basis for the current year, the budget year, and the five succeeding years. Later, in the evolution of the Program Control System, the control schedules were extended to cover all programs authorized for construction, regardless of the completion date. In addition, program estimates were made on a six-month basis. This permitted rapid conversion of estimates from a fiscal year to a calendar year for use in the Bulletin No. 132 series. This series is an annual report of the Department prepared on a calendar year basis to document management actions, summarize construction and operations progress during the year, update long-range financial projections, and provide data and computations in support of charges to be assessed to water users.

TEHACHAPI DIVISIO

Line No.	Cost Classification	Program Item	Estimated Total	Total to 7-1-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	Balance to Complete	Estimated Completion Date	Line No.
1	6154.2311	A. D. Edmonston Pumping Plant S.C.	12,849	12,1[illegible]	403 301	14[illegible] 25	24 36	8		3	52 93	See next page.		1
2		Earned D.F.	[illegible]	81,248	361 1,647	165 20	110 342			17	30[illegible] 75[illegible]	See next page.		2
3		Cash D.F.	1[illegible],324	77,47[illegible]	338 5,367	175 91	9[illegible] 362			[illegible]	26 [illegible]	See next page.		3
4														4
5		Initial Contract S.C.	2,388	2,381	2 5									5
6		Earned D.P.	22,458	22,458										6
7	154-10-10	Cash D.F.	22,458	22,458										7
8														8
9		Pumps, First Contract S.C.	[illegible],33[illegible]	1,12[illegible]	21 76	1								9
10		Earned D.F.	14,12[illegible]	13,993	1 117									10
11	154-[illegible]-25	Cash D.F.	14,12[illegible]	12,78[illegible]	19 1,321									11
12														12
13		Pumps, Second Contract S.C.	744	673	31 24	2								13
14		Earned D.F.	7,44[illegible]	7,422	223									14
15	154-[illegible]-20	Cash D.F.	7,445	[illegible]	58									15
16														16
17		Motors, First Contract S.C.	[illegible]12	[illegible]	15 23									17
18		Earned D.F.	[illegible]	[illegible],33[illegible]	9 234									18
19	154-[illegible]-35	Cash D.F.	[illegible]	[illegible]	[illegible],13[illegible]									19
20														20
21														21
22														22

REMARKS
COSTS SHOWN IN $1,000

MAJOR ACTIVITIES
1 PLANNING
2
3 SERVICES
4 DESIGN
5 RIGHT OF WAY
6 CONSTRUCTION
7 DIRECT OPERATION AND MAINTENANCE
8 GENERAL OPERATION AND MAINTENANCE
9 ADMINISTRATION

Prepared Program Liaison & Control Office date 4-1-74
Recommended ________ date ________
Recommended ________ date ________
Recommended ________ date ________
Approved ________ date ________
Revised ________ date

DEPARTMENT OF WATER RESOURCES
CONTROL SCHEDULE
CASE II-M-74
STATE WATER PROJECT
date APRIL 1, 1974

Figure 2. Control Schedule

In April 1967, the Governor's Water Resources Task Force published a report pointing up possible funding deficiencies for the Project due to inflationary trends. Details of this possible funding deficiency are described in Volume I of this bulletin.

Following this, the Department initiated a series of detailed studies which increased the emphasis on the use of control schedules and provided management with information that enabled them to exercise more current controls over capital expenditures. In addition, procedures were initiated to permit project costs to be updated on a monthly basis to provide a reasonably accurate, current estimate of the Project's financial status. This approach was useful not only to determine the Project's current financial status in relation to the work still to be done but also aided in program planning, since the effect of any given decision on the financial situation could be evaluated rapidly. These changes were reflected when new annual control schedules were prepared.

In practice, control schedules are reviewed through the management channels of the organization, eventually providing the input to the Department's annual Program Conference. This conference, attended by upper management personnel, provides an opportunity for a thorough discussion of program proposals and policy with the Director. The conference results in the approval of programs and control schedules reflecting the Department's future program direction. The policy established is also reflected in the Bulletin No. 132 series.

Program Statement

A program statement is a narrative description of each individual program element including the date the work started, progress during the past year, expected progress in the current and following years, the anticipated completion date, and a summary of cost data. Essentially, the information contained in the program statements supplements the control schedules.

Work Authorization

The control schedule identifies the approved program of the Department. The authority to proceed with the work is provided by a work authority document to control the execution of the program. A separate work authority, which defines the scope of the work, is prepared for each distinctive program element for each fiscal year. It defines the responsibility for carrying out the program and provides a specific allocation of funds to accomplish the work. No work can be initiated, terminated, transferred, or significantly changed in scope, nor can additional funds be allocated or expended, without an approved work authority. The work authority, prepared by the line organization responsible for managing the work, is approved by a Deputy Director. Under certain circumstances, the document may require approval by the Department of Finance.

Management Reports

The Program Control System reports include an accounting report and a Progress Report, State Water Project. The accounting report, designated the Program Managers Report, is issued monthly, approximately the 15th of the month, by the Department of Water Resources Comptroller. It contains detailed information by work authority on expenditures, allotments, and remaining balances.

The Progress Report, State Water Project, contains information of interest to various levels of management, including fiscal and personnel data, as well as a status report on design, construction, right-of-way, operations and maintenance, and special studies. The report is distributed monthly and is reviewed at the Director's Executive Staff meeting. Initially, the report was reviewed every month but later, in the 1970s, on a bimonthly schedule. For the most part, the review concentrates on areas showing significant deviation from plan, utilizing the management-by-exception principle. To facilitate the identification of program deviations, a "black ball" is printed to highlight noteworthy items. Line managers attending the staff meeting are expected to identify the roadblocks that must be resolved and discuss plans to correct the deviations.

Cost Classification

Through a system of cost classification, all of the Department's programs are identified and classified by a standard numbering system coded for machine operations. This system is used in program estimates and control schedules. It appears on work authorities and final reports to management. Cost classification is the common language of all elements of the Program Control System.

Program Management Technique (PROMT)

The Program Control System just described provides an excellent means to develop, monitor, and control department programs in terms of cost and scope, as well as a means for scheduling in a broad sense. However, it was not designed for detailed and comprehensive scheduling needed to integrate the complex activities related to the design and construction of a facility of the magnitude of the State Water Project. Furthermore, the Program Control System does not include any procedures for manpower management, particularly where a large and varied number of programs must be accomplished during a given period and where the organization manager must have some means of planning to relate manpower resources to program needs.

The need for a more comprehensive management system to operate within the Program Control System, particularly in the area of scheduling, was recognized in 1961 shortly after the implementation of the Program Control System. Following the submission of proposals in 1962, the firm of Management Systems Corporation was retained to develop a management system utilizing the critical path method of scheduling. The consultant initiated activity in March 1963 and submitted a report in June 1963 (Reference 2). The consultant's contract was extended through January 1964 to permit him to provide assistance to the Department in the implementation of the system.

The management system was given the title Program Management Technique, with the acronym PROMT It provides a method to interrelate the schedule for design, construction, and right-of-way activities on the State Water Project, with the other management parameters of manpower and funds. The system is supported by computer-developed reports on a program basis and on an operating unit or organizational basis, suitably summarized to provide pertinent information to various management levels. Figure 3 indicates the major elements of the PROMT system and their interrelationship.

Scheduling

The PROMT system provides the time durations of the activities needed to complete various elements of the Project. The durations are developed from networks and shown in the computer-developed activitiy listing (Figure 4). Network scheduling is, for the most part, accomplished using the Critical Path Method (CPM), although Pert and Precedence networks are also used, particularly in contractors' construction schedules.

The purpose of the network is to present, in logical sequence, the activities necessary to achieve program objectives. These objectives were defined by water delivery dates established in the water supply contracts and power delivery commitments. Planning, design, right-of-way acquisition, construction, and operations activities are scheduled around these project control dates. Subordinate dates, designated control events, are used to signify the beginnning or the end of a major activity, such as design or construction restraint dates. Events subordinate to control events are used as required. The networks are generally of two levels, the control network and the more detailed program network. For specific purposes, even more detailed networks have been developed for selected parts of a program, for example a contractor's construction schedule or a right-of-way schedule.

Control Network. The control network relates the dates by which control events should take place. It provides an excellent framework of the Project's overall schedule and is used widely for reference purposes by management. Control networks are developed cooperatively by the organizations involved in the activities displayed on the net and represent a summary of their plan to accomplish the work within their delegated responsibility. An example of a control network is shown on Figure 5.

Program Network. The control network presents only a summarized schedule rather than the plan for each program element. The detailed work plan is developed on the program network. This network incorporates the activities of all participants. Such a network might be represented by an element or a single line on a control network. Each element of a control network is assigned to a specific program manager, usually located in the organization responsible for the major portion of the work. This manager is responsible for developing and periodically updating the program network. The program manager is provided technical assistance and advice in the formulation of the network by a representative of a program control office of the Department. An example of a program network, as it appeared during the design phase, is shown on Figure 6.

A computer listing of all activities related to any individual program network is presented on the activity listing report previously mentioned (Figure 4). This report, which includes pertinent dates as well as identifying available float (time available in excess of that needed to complete a task), is used to facilitate network analysis. It also provides a method of updating the networks.

During the design and right-of-way procurement phases of a program, the activities are accomplished by department personnel, which facilitates scheduling and monitoring. After award of a contract, however, activities are under the control of the contractor, who develops his own schedule within specific dates included in the contract specifications. To enable the necessary interface with departmental activities as well as activities of other contractors, the specifications provide that the contractor submit his schedule in the form of a CPM or Precedence diagram, together

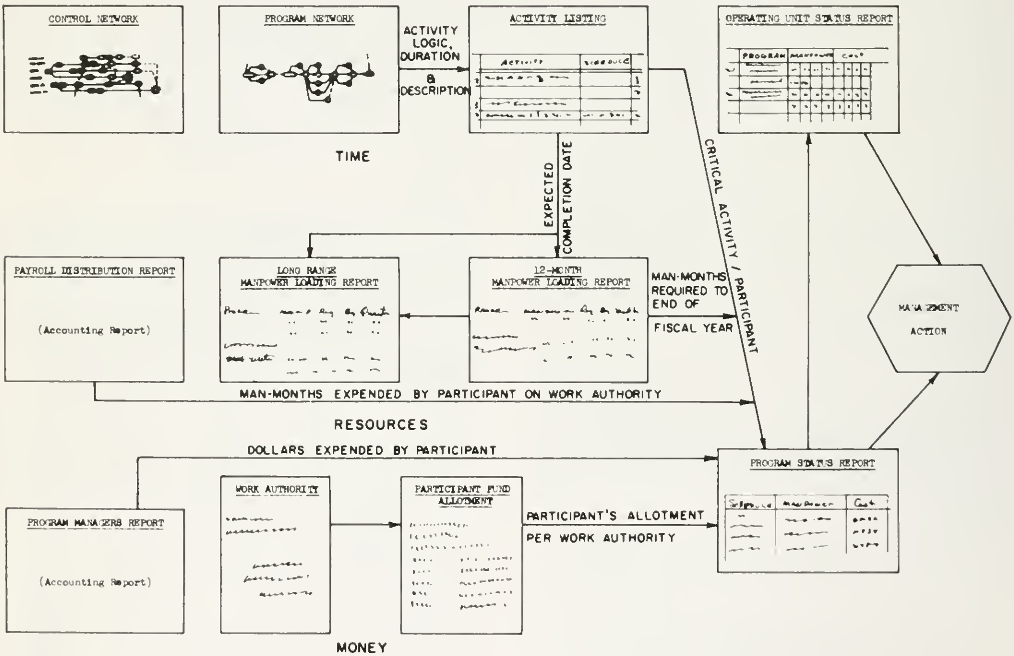


Figure 3. Major Elements of PROMT

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

10

ACTIVITY LISTING

ID NO	PROGRAM DESCRIPTION	P.C.
55	WIND GAP P.P.-PUMPS	11

OP	SORT	RUN DATE	RUN	PART NO	PARTICIPANT DESCRIPTION	NO	PROJECT DIVISION
		6/18/70	3			153	SOUTH SAN JOAQUIN

CODE	BEGIN NODE	END NODE	DURATION WKS	W.A. OR MILESTONE	PARTICIPANT	ACTIVITY	SCHEDULED COMPLETION	EXPECTED START	EXPECTED FINISH	ATE START	ATE FINISH	TOTAL FLOAT
	7126	7200	.6	6040	3890	FINAL ALIGNMENT	10/ 2/70 •	4/13/70	4/28/70	4/17/70	4/22/70	.6
	7127	7200	1.0	6040	3890	WELD DUCT TUBE TO CASING	C	4/15/70	4/22/70	4/15/70	4/22/70	.0
	7200	7202	3.0	6040	3890	EMBED PUMP-BY OTHERS	C	4/22/70	5/13/70	4/22/70	5/13/70	.0
	7200	7209	.0	0	0000	ELAPSED TIME	C	4/22/70	4/22/70	6/ 1/70	6/ 1/70	5.6
	7200	7210	.0	0	0000	ELAPSED TIME	C	4/22/70	4/22/70	6/ 1/70	6/ 1/70	5.6
	7200	7211	.0	0	0000	ELAPSED TIME	C	4/22/70	4/22/70	6/ 8/70	6/ 8/70	6.6
	7202	7203	1.0	6040	3890	REMOVE TEST RING-COVER	C	5/13/70	5/20/70	5/13/70	5/20/70	.0
	7203	7204	2.0	6040	3890	S.BLAST-COAT T.COVER-END PTS	C	5/20/70	6/ 3/70	5/20/70	6/ 3/70	.0
	7204	7206	.8	6040	3890	INS ROT ELEMENT IN CASING	C	6/ 3/70	6/ 8/70	6/ 3/70	6/ 8/70	.8
	7206	7208	.6	6040	3890	INS TOP COVER	C	6/ 8/70	6/11/70	6/ 8/70	6/11/70	.0
	7208	7300	.4	6040	3890	CLN-INS SPG BOX-BEARING	1/ 8/71 •	6/11/70	6/15/70	6/11/70	6/15/70	.0
	7209	7300	2.0	6040	3890	INS MSC SML ITM	C	4/22/70	5/ 6/70	6/ 1/70	6/15/70	5.6
	7210	7300	2.0	6040	3890	INS EXPOSED PIPING	C	4/22/70	5/ 6/70	6/ 1/70	6/15/70	5.6
	7211	7300	1.0	6040	3890	TOUCH UP PAINTING	C	4/22/70	4/29/70	6/ 8/70	6/15/70	6.6
	7300	7302	4.0	6040	3890	INS-MOTOR-CONN TO PUMP	I	6/15/70	7/13/70	6/15/70	7/13/70	.0
	7302	7304	1.0	6040	3890	PRE-TEST FINAL CHECK	4/ 2/71 •	7/13/70	7/20/70	7/13/70	7/20/70	.8
	7304	7999	2.0	6040	3890	OPERATIONAL TEST PUMP NO. 7		7/20/70	8/ 3/70	7/20/70	8/ 3/70	.8
	8000	8001	.0	0	0000		3/31/70 C	3/31/70	3/31/70	3/31/70	3/31/70	.0
	8000	8102	.0	6040	0000	SHIP PUMP NO. 8 TO OKGRLD	3/31/70 C	3/31/70	3/31/70	3/31/70	3/31/70	.0
						CONTINUED						

Figure 4. Activity Listing

with a printout, and update it periodically. On receipt of such a schedule, pertinent activities and dates are incorporated into the Department's program network.

Project Progress Review and Control. A major advantage of a network-type schedule is that it can be used to determine whether the plan can meet the desired target dates and, if not, identify the critical areas where adjustments must be made. The Department has utilized this aspect of the system extensively for over a decade in successfuly meeting its schedule objectives.

Initially, beginning in early 1964, there was a series of formal monthly meetings attended by various Division Chiefs of the Department and their key staff members. These briefings concentrated on lagging programs identified from an analysis of updated networks and usually resulted in directed courses of action to overcome the problems identified.

Beginning in the spring of 1967, a less formal approach was adopted to focus on critical problem areas, particularly in construction. At that time, it was apparent that the activities necessary to permit the closure of the diversion tunnels at Oroville Dam in the fall of 1967 were encountering numerous schedule difficulties. A small ad hoc committee, the Oroville Closure Committee, was appointed with the responsibility and authority to take the actions required to solve these problems. It met as often as necessary, usually weekly, and was successful in bringing about the scheduled closure and initial storage of water.

The success of the Oroville Closure Committee resulted in the appointment in the spring of 1968 of a similar committee, the Power and Water Delivery Committee. This committee was charged with developing solutions to numerous problems affecting the schedule for water deliveries from the California Aqueduct. Because problems on the Aqueduct directly affected, and were affected by, construction activities of the City of Los Angeles Department of Water

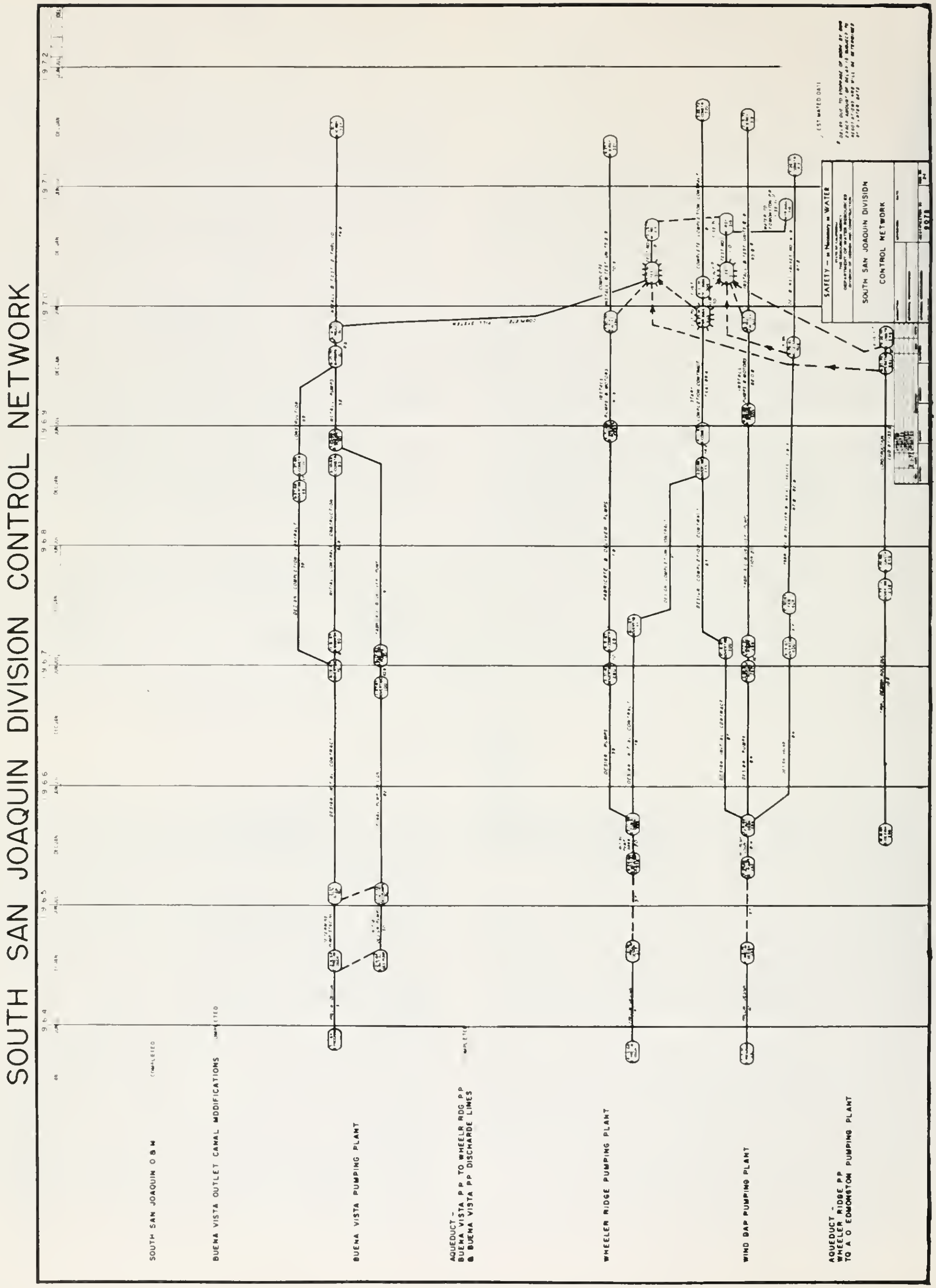


Figure 5. Control Network

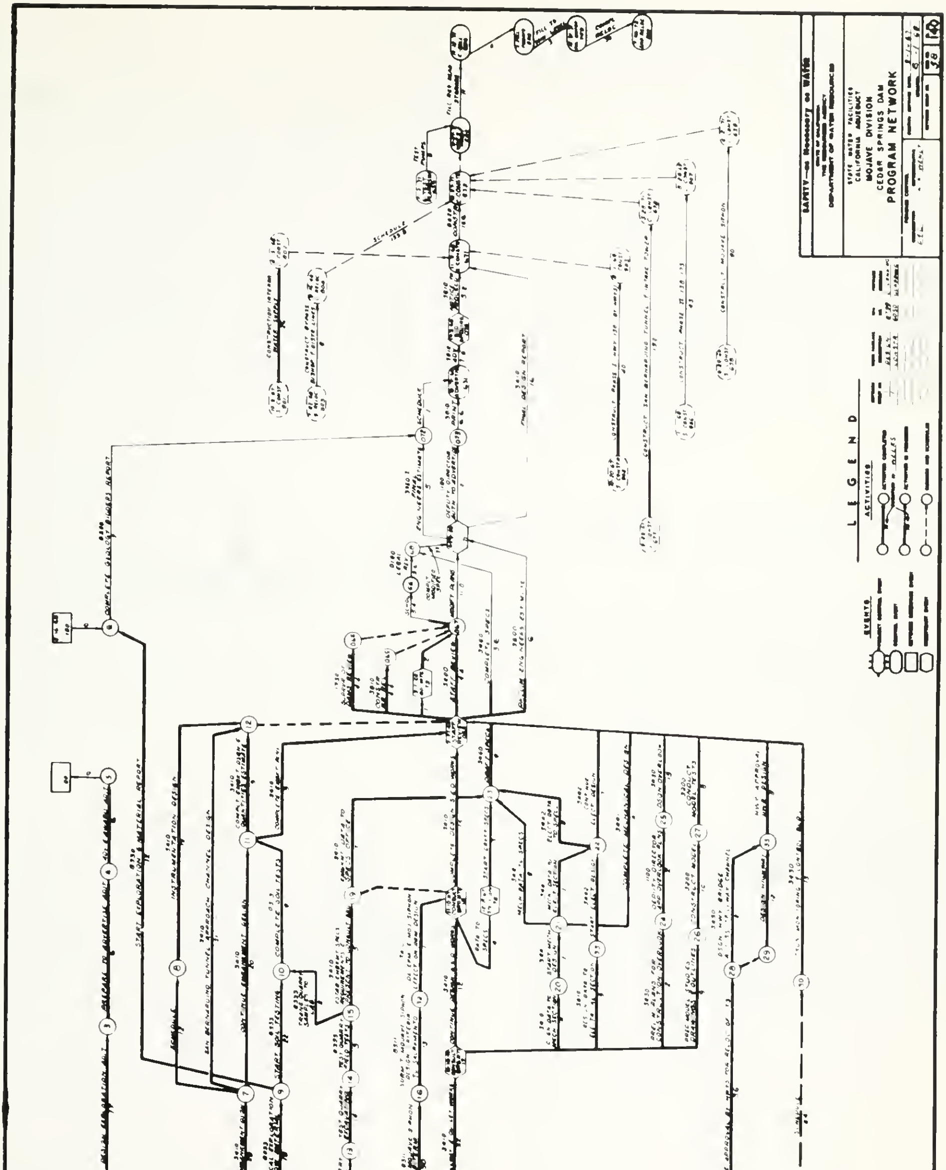


Figure 6. Program Network

and Power at Castaic Powerplant and The Metropolitan Water District of Southern California, principally at Castaic Dam, representatives of these agencies met with the committee.

Manpower Planning

Manpower planning to accommodate the project schedule was a major management challenge. It involved not only the availability of specific skills or disciplines to meet the various program deadlines but also the adjustment of assignments to avoid large fluctuations in unit workload. To provide ongoing assistance in the solution of this problem, a manpower planning subsystem was incorporated into PROMT. Three reports were included: a 12-month report and a 3-year report, both arranged around program and organization, and a 3-year report arranged around disciplines.

The principal manpower report from a program standpoint is the 12-month Manpower Requirement Report (Figure 7). The input to this report is developed on an organizational basis on a Manpower Loading Report (Figure 8). This latter report lists programs the designated organization will be participating in during the next 12-month period, together with the expected completion date of each activity. The organization supervisor estimates, in terms of man-months, the effort his organization will expend on each program during each of the months in the ensuing 12-month period. Each program manager, through a compilation of the data on a program basis, is advised of the effort to be expended on his program in the next 12 months through computer-developed reports resulting from this input.

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

MANPOWER REQUIREMENT REPORT

REPORT DATE	D NO	PROGRAM DESCRIPTION	NO	PROJECT DIVISION
NOV 01, 1969	123	A.D. EDMONSTON PP DISCH LINES (67-02)	154	TEHACHAPI

NO	WORK AUTHORITY DESCRIPTION
6089	CONST A.D. EDMONSTON PP DISCHARGE LINES

PARTICIPANT DESCRIPTION	PARTICIPANT NUMBER	EXPECTED COMPLETION DATE	MANPOWER REQUIREMENTS BY MONTHS P/MO	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
D•C AQUEDUCT DESIGN UNIT NO 2	3610.3	/ /	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	.5	.5	.5	
D•C INSTRUMENTATION	3610.6	/ /	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	
D•C ENGINEERING ANALYSIS	3610.7	/ /	.1	.1	.1	.1	.1	.1			.1	.1	.1	.1	
D•C ENGINEERING ANALYSIS	3610.7	/ /	.1	.1	.1	.1	.1	.1		.1	.1		.1	.1	
D•C ENGINEERING ANALYSIS	3610.7	/ /												.2	
D • C PROJECT GEOLOGY	3483	/ /	1.3	1.4	1.4	1.6	1.6	1.6	1.6	1.6	1.6	1.0	1.0	1.0	1.5
D•C MECHANICAL DESIGN - PUMPING	3641.2	/ /													
D•C ELECTRICAL DESIGN - PUMPING	3642.2	/ /							.5	.5	.5		.5		
D • C CONST CONTROL • MANAGEMENT	3805	06/30/71	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	
D • C OFFICE ENGINEERING	3810	12/ /70		.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
D • C - EQUIP • MATERIALS SECTION	3830	06/ /76	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
D • C - S SAN JOAQUIN PROJECT OFFICE	3890	06/30/76	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
SO.DIST.-D•C-MECHANICAL DESIGN UNIT	6314	04/28/71	.1	.1	.1	.1	.1	.1							

PROGRAM MANAGEMENT TECHNIQUE MANPOWER REQUIREMENT REPORT

Figure 7. Manpower Requirement Report

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

MANPOWER LOADING REPORT

REPORT DATE	AUTHORIZED POSITIONS	VACANT POS	ORGANIZATION DESCRIPTION	ORGANIZATION NO
NOV 01, 1972	44	1	G+C CONSTR CONTRACT ADMIN SECTION	3080

DIV NO	ID NO	PROGRAM DESCRIPTION / WORK AUTHORITY DESCRIPTION	EXPECTED COMPLETION DATE	P/MO	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
156	0169	PERRIS DAM + RESERVOIR 6117 CONST-PERRIS DAM + RESERVOIR	10/30/73		3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.5	1.5	1.5	1.5
156	0165	DEVIL CANYON POWERPLANT 6 13 CONSTR-DEVIL CANYON POWERPLANT	10/ /75		2.5	2.5	2.5	2.0	2.0	2.0	2.0	1.8	1.0	1.0	1.0	1.0
156	0421	PERRIS O+M CENTER 6111 CONST-PERRIS O+M CENTER	06/ /77			.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
156	0522	AQUE-HILL ST TO SUGARLOAF MTN 6109 CONST-AQUE HILL ST TO SUGARLOAF MTN	06/ /72													
156	0541	AQUE-SUGARLOAF MTN TO LAKE PERRIS 611 CONST-SUGARLOAF MTN TO LAKE PERRIS	04/ /73		1.5	1.5	1.5	1.[illegible]	.8	.8	.2					
157	0168	OSO PUMPING PLANT 6 24 CONST OSO PUMPING PLANT	06/ /73													
157	0200	PYRAMID DAM 6 94 CONST-PYRAMID DAM	12/ /73		2.0	2.0	2.0	2.0	2.0	2.0	1.5	1.5	1.0	1.0	1.0	1.0
157	0515	ANGELES TUNNEL 6752 CONSTRUCTION-ANGELES TUNNEL	03/ /74		1.5	1.0	.9	.4	.4	.4	.4	.4	.4	.4		.2
157	0597	CASTAIC DAM+RESERVOIR, EMB + SPILLWAY 6 20 CONSTR.-CASTAIC DAM + RES + OUTLET	12/ /73		1.5	1.5	1.5	1.0	1.0	1.0	1.0	1.0	.8	.6	.5	.5
500	0700	RECLAMATION BOARD PROJECTS 1850 R/W ACQUISITION	/ /		1.0	1.0	1.0	3.0	3.0	3.0	3.0	3.0	7.0	7.0	7.0	7.0
			TOTAL	.0	4[illegible].1	38.5	35.7	35.2	35.2	34.2	33.1	31.4	38.0	31.3	30.0	29.6

PROGRAM MANAGEMENT TECHNIQUE MANPOWER LOADING REPORT

Figure 8. Manpower Loading Report

Short-range manpower estimates are required for program planning purposes, but long-range estimates are needed for purposes of proper staffing. In order to meet these separate needs, two additional reports are prepared. One is similar to the manpower loading report just described, except that it is for quarterly periods for the next three years. The second of these, also for a three-year period, is estimated by discipline rather than program. These long-range reports were of particular importance during the period of staffing reduction, which occurred in a five-year period following the peak employment period in 1967.

Funds

Expenditure planning and control are among the most important functions of a program manager. PROMT was designed to assist the manager in forecasting his fiscal needs, based on program schedule and manpower requirements. In accompishing this, PROMT provided for interface with, and dependency on, other systems of the Department, notably the Program Control System and the accounting systems.

An important fiscal document for the PROMT system is the work authority developed for the Program Control System. This document allots funds to the program manager on a fiscal year basis to accomplish the work defined for that year. Since the accomplishment of programs depends, in part, on technical participation by other functional units, a method was developed for the program manager to further authorize expenditures to specified limits by these participants. This document, called a participant fund allotment, is used not only for the PROMT system but also incorporated into the Department's program accounting system.

The estimated cost of any individual program for a given fiscal year is comprised of two elements. The first is the already incurred cost for the fiscal year, which is available in the Department's program cost accounting system. The other consists of an estimate of cost for the balance of the year. The element for state operations activities is developed from the projected monthly manpower requirements as estimated by each of the participants in the program and converted to fiscal requirement by use of an average cost factor developed for each of the participant organizations. The direct-pay items are geared to expected construction progress payments or control dates governing right-of-way availability. The sum of these values provides the program manager considerable insight to total anticipated expenditures for the fiscal year.

PROMT Status Reports

There are two categories of key status reports in the PROMT system—program or project reports and organization reports. These are generated by electronic data processing equipment from the latest available information in the activity listing, manpower loading report, participant allotment, and accounting reports. Each of the PROMT status reports was designed to show the predicted results of current progress and future needs compared with approved allocations, using the three management parameters of time, manpower, and funds.

Program Status. The Program Status Report (Figure 9) was designed to assist each program manager in monitoring the schedule, manpower, and cost within his program. It provides, in summary form, the pertinent information needed to evaluate the status of his program and to make a judgment as to any corrective action that may be required. The schedule portion of the report informs the program manager of the work of each of his participants. Those participants working on the more critical activities, i.e., those with the least amount of float, are shown first. The manpower and cost portions of the report compare expended and required amounts with authorized amounts and alert the program manager to possible over- and underexpenditures well in advance.

Operating Unit Status. The Operating Unit Status Report (Figure 10) was designed to assist each operating unit head in monitoring his schedule, manpower, and cost for each program in which his organization is a participant. Essentially, this report provides the operating unit head with the same information that the program status report provides to the program manager, except in more detail and more specifically related to his area of interest.

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

PROGRAM STATUS REPORT

REPORT DATE: JUL. 31, 1966 — ID NO: 44 — PROGRAM: BUENA VISTA PUMPING PLANT — FISCAL YR: 1967 — NO: 53 — PROJECT DIVISION: SOUTH SAN JOAQUIN

WORK AUTHORITY NUMBER	PARTICIPANT NUMBER	PARTICIPANT DESCRIPTION / CRITICAL ACTIVITY	SCHEDULE: LATEST COMPLETION	SCHEDULE: EXPECTED COMPLETION	SCHEDULE: FLOAT WEEKS	MANPOWER — MAN MONTHS: AUTHORIZED FISCAL YR	MANPOWER: EXPENDED FISCAL YR	MANPOWER: BALANCE REQUIRED	MANPOWER: OVER UNDER	COST (1000 DOLLARS): AUTHORIZED FISCAL YR	COST: EXPENDED FISCAL YR	COST: BALANCE REQUIRED	COST: OVER UNDER
641		41 DESIGN—BUENA VISTA PUMPING PLANT				170.2	155.5	0.0	-14.7	270.0	240.5	0.4	-29.1
	3450	D & C - STRUCTURAL DESIGN ARCH&STRUCT DESIGN	10/07/66	10/07/66	0	47.9	51.5	0.0	3.6	76.2	78.0	0.0	1.8
	3200	D & C - STAFF ENGINEERING BRANCH CORROSION CONSULTATION—STRUC	12/02/66	12/02/66	0	2.9	2.9	0.0	0.0	4.9	3.3	0.0	-1.6
	3441	D & C - MECHANICAL DESIGN MECH EQUIP—PLANS&TECH SPECS	2/24/67	2/24/67	0	48.9	37.4	0.0	-11.5	72.2	49.5	0.0	-22.7
	3442	D & C - ELECTRICAL DESIGN ELECT EQUIP—PLANS&TECH SPECS	2/24/67	2/24/67	0	57.0	57.9	0.0	0.9	83.8	79.9	0.1	-3.8
	3460	DIV D&C-SPECIFICATIONS OFFICE PRELIM DRAFT STRUCT SPECS	2/24/67	2/24/67	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3600	D & C - PROJECT GEOLOGY BRANCH PREP GEOLOGIC PRECONSTR REPT	6/23/67	3/17/67	14	13.1	5.8	0.0	-7.3	31.9	28.9	0.0	-3.0
	1210	POWER OFFICE - POWER CONTRACTS BR NEGOT POWER CONTRACT	11/15/68	11/18/66	104	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3100	D & C - OFFICE OF DIVISION ENGINEER				0.4	0.0	0.0	-0.4	1.0	0.6	0.3	-0.1
	3410	D & C - DAM DESIGN				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3450	D & C - AQUEDUCT DESIGN				0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2
	3850	D & C - SOUTH BAY PROJECT OFFICE				0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1

DWR 1835 (REV. 3/65)   PROGRAM MANAGEMENT TECHNIQUE   PROGRAM STATUS REPORT

Figure 9. Program Status Report

Effectiveness of Management Systems

The effectiveness of the Program Control and PROMT Systems is proportional to the utilization and reliance by the various levels of management on the system to meet information needs. Portions of each of the systems are used more extensively than others; however, the fact that the Project met a schedule that was established in 1961, and that the Department was able to accomplish the construction within available funding, is attributable in large part to management's use of the information derived from the management systems developed for the Project.

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

OPERATING UNIT STATUS REPORT

REPORT DATE: JUL. 31, 1966 — FISCAL YR: 1967 — SECTION: O & C - OROVILLE PROJECT OFFICE — SECTION NO.: 3840

Work Authority Number	Program Description / Critical Activity	Schedule: Latest Completion	Schedule: Expected Completion	Float Weeks	Manpower — Man Months: Authorized Fiscal YR	Expended Fiscal YR	Balance Required	Over + Under	Cost (1000 Dollars): Authorized Fiscal YR	Expended Fiscal YR	Balance Required	Over + Under
	PONDEROSA DAM & MINERS R. CANAL											
501	DESIGN				0.0	9.3	0.0	9.3	0.0	11.1	0.0	11.1
	SCHEDULED TIME	4/01/66	10/28/66	-30								
001	CONSTRUCTION				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	FIELD PREP & PRECONSTR SURVY	8/19/66	3/17/67	-30								
	B. ABBOTT GOLDBERG BRIDGE											
665	CONSTRUCTION				139.5	124.2	0.0	14.7	139.5	204.2	2.5	65.2
	FAB FORMS&INSTALL STEEL	5/17/66	7/04/66	-7								
	THERMALITO POWERPLANT											
642	CONSTRUCTION				539.4	463.6	0.0	-75.6	577.2	607.6	2.2	32.6
	DELIVER SUPER STRUCT STEEL	6/24/66	7/01/66	-1								
	GRIZZLY VALLEY DAM & RES											
731	CONSTRUCTION				378.3	211.3	0.0	-167.0	378.3	315.1	6.0	-57.2
	ACTIVATE QUARRY ZONE 3	7/01/66	7/01/66	0								
	THERM POWER CANAL											
728	CONSTRUCTION				245.8	218.0	0.0	-27.8	245.8	271.4	2.2	27.8
	LEAD TIME	9/30/66	9/30/66	0								
	THERMALITO DIVERSION DAM											
656	RIGHT OF WAY				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	PG&E CONST TWR PROTECTION	10/28/66	10/28/66	0								
	OROVILLE QUINCY CO RD RELOCATION											
627	CONSTRUCTION				64.9	15.6	0.0	-49.3	64.9	25.8	9.5	-29.6
	CONST BRIG & RD TO PASS TRAF	11/04/66	11/04/66	0								
	CONTINUED											

DWR 1958 — PROGRAM MANAGEMENT TECHNIQUE — OPERATING UNIT STATUS REPORT

Figure 10. Operating Unit Status Report

References

(1) California Department of Water Resources, "Plan for Program Control in Department of Water Resources", May 1961.

(2) Management Systems Corporation, "Project Management System Design", a report to the State of California, Department of Water Resources, June 1963.

CHAPTER II. RIGHT OF WAY

The Division of Land and Right of Way of the Department of Water Resources, centered in Sacramento, is responsible for the real estate transactions associated with the State Water Project. Properties acquired have ranged in size from fractions of an acre to thousands of acres. In addition, railroads, power and communication lines, pipelines, freeways, and a hydroelectric power plant have been acquired, relocated, or dismantled, as described in Chapter III of this volume.

Organization

From 1960 to 1963 and 1965 to 1971, appraisals and negotiations on private parcels were handled by the Division of Highways of the Department of Public Works (now the Department of Transportation) under interagency agreements; public agency and utility transactions were conducted by Department of Water Resources staff. Interagency agreements also were in effect with the Office of the Attorney General, who provided legal assistance to the Department on condemnation matters. Control agency review services for real estate transactions of the Department were provided by the Division of Highways through delegation from the Department of General Services.

Authorities

Department authorities for property acquisition, management, and disposal are contained in various sections of the Water Code commencing with Section 250 wherein the Department is authorized to condemn property under the eminent domain provisions of the Code of Civil Procedure upon declaration of public interest and necessity by the Director and concurrence by resolution of the California Water Commission. If claims of severance damage arise, a whole parcel may be purchased and the unnecessary remainder sold or exchanged for other property needed. Under the Central Valley Project sections of the Water Code commencing with Section 11580, the Department also is authorized to acquire and dispose of property in a manner similar to the earlier statutes.

Section 11590 limits the Department in the taking or destruction of railroads, other public utilities, and other state facilities until substitute facilities of like character and at least equal in usefulness are completed or agreement is reached with the owner. Adjustment for any increase or decrease in the cost of operation and maintenance of the substitute facilities is also authorized.

The Department is directed to plan for and acquire land for recreation and fish and wildlife enhancement in Section 345 of the Water Code, and the sections beginning at 11910 provide detailed guidance during the planning and construction of projects. Water Code Section 346 affirms and clarifies the right of the Department to " . . . acquire by eminent domain or otherwise, either in fee or in any lesser estate or interest, any real property for recreational development associated with state-constructed water projects." The Legislature made it clear that no Department of Water Resources development funds will be appropriated for the purpose of acquiring land for recreation development exclusive of land required for storage and conservation of water projects. Accordingly, provision was made in Article 4 for reimbursement for the cost of acquiring such recreation lands. Under Section 11915.5, the Department is authorized to exchange for the purpose of furthering recreation any property it has acquired for land owned by the United States within the State of substantially equal value. Pursuant to this section, the Department is pursuing appropriate exchanges in both Northern and Southern California in coordination with the Department of Parks and Recreation and the U. S. Forest Service.

Acquisition

General

Parcels which have been acquired vary in size from partial takings as small as 45 square feet to full acquisition of properties as large as 6,000 acres. The length of state right of way through individual properties ranges from as small as 20 feet to as long as 25 miles. In the various land interests and categories, total acreages are as follows:

Fee	89,205 acres
Easement, permanent	6,101 acres
Easement, temporary	2,445 acres
*License	
FPC No. 2100	41,272 acres
FPC No. 2426	20,000 acres
**Recreation Land	24,557 acres
Excess Lands	9,242 acres

* Federal Power Commission (FPC) License No. 2100 consists of 6,289.69 acres of U.S. lands and 34,983 acres of private lands. FPC License No. 2426 acreages are not fully settled but at this time (9/74) they are approximately 12,000 acres of U.S. lands and 8,000 acres of private lands.

** Note: Some recreation lands were acquired in fee; some are interests obtained under the FPC license procedure.

Among the types of property acquired for the Project are public utilities and public facilities; mountain cabin sites; merchantable timber lands; desert properties; grazing lands; irrigated and nonirrigated agricultural lands; orchard lands; urban and suburban industrial, commercial, and residential properties; and public-owned lands.

The following are examples of the types of ownerships affected during the course of land acquisition for the Project:

1. Federal agencies, including the U. S. Forest Service and the Bureau of Land Management as well as the United States Navy;
2. State agencies, including the Division of Highways and the Department of Parks and Recreation;
3. Counties, cities, and special districts;

4. Public utilities, including railroads, power companies, water and gas companies, and telephone utilities;

5. Municipal and quasi-municipal agencies, including water, power, sewer, flood control, road, irrigation, and reclamation agencies;

6. School districts and private universities; and

7. Private owners ranging from agricultural corporations and oil companies to individual citizens.

In approximately 90% of the acquisitions, scheduled deadlines have been extremely tight. Court orders for immediate possession and rights of entry from property owners have been used extensively to permit construction prior to completion of negotiations with property owners.

In the various acquisitions, all or some of the following actions have been required:

1. Alignment and minimum acquisition lines secured.

2. Entry permits for geologic exploration negotiated and obtained from property owners.

3. Property boundaries and ownership information obtained through county assessor offices and title companies.

4. Field surveys made specifically to identify property boundaries and acquisition lines.

5. Right-of-way maps for appraisal and negotiation purposes prepared.

6. Security deposit estimates and negotiation appraisals prepared.

7. Meetings held with property owners to explain the effects of acquisition on their properties.

8. Department of Water Resources Director's Declarations of Necessity obtained.

9. Property owners notified of impending condemnation actions.

10. California Water Commission concurrence with Director's Declaration obtained.

11. Condemnation Security Deposits made in court.

12. Documents prepared by the Attorney General's Office filed with the courts and served on property owners.

Policy as to Advance Information

The Department realized that during construction of project facilities there would be a disruptive impact on other areas of government and on private property owners along the project right of way. Special effort was made to inform the various levels of government and to alert property owners as to the Department's plans and progress. Comments were solicited to provide input on the impact of the program.

Where state facilities necessitate removal or replacement of roads, advance agreements with the affected city or county provide for abandonment of any obsolete facility, replacement of those facilities still needed, and installation of bridges and turnarounds where required. Where federal lands are entered, particularly at reservoirs, Memoranda of Understanding are negotiated with responsible federal agencies which spell out the uses to which the land will be put and the restrictions under which the Department will function in these areas.

Construction of the State Water Project sometimes affects existing water and electrical facilities. When this is foreseen, advance agreements give assurance that the Department will install interim facilities so that supplies will not be interrupted.

Location and Cost of Acquisitions—Summary

The following tabulation outlines, by Division or Feature, the lands and improvements acquired for the State Water Project:

Division or Feature	Estimated Total Cost (in $1,000)	Estimated Total Parcels
Upper Feather	1,899	29
Oroville	41,859	946
North Bay I	77	13
II (authorized)	533	25
II (future)	163	49
Delta—Borrow	1,955	23
Delta—Future	*	146
South Bay	4,845	202
North San Joaquin	9,137	208
San Luis Reservoir and O'Neill Forebay	6,790	22
South San Joaquin	4,556	562
Coastal	2,195	48
Tehachapi	545	1
West Branch	13,647	300
Mojave	16,119	1,636
Santa Ana	17,350	684
Total	121,670	4,894

Major Acquisitions

Oroville Borrow Area. Approximately 5,500 acres of gold dredge tailings south of Oroville along the Feather River were acquired to provide fill material for the construction of the earthfill embankment comprising Oroville Dam. In one of the larger acquisitions —the Natomas Company property—the Department received court support confirming that, even though the borrow area was more than 7 miles outside the reservoir area, the taking was for "reservoir purposes" under the State Constitution. This meant immediate possession could be obtained pursuant to the Code of Civil Procedure. The court also upheld the right of the State to acquire the land rather than purchase the material on a yardage basis even though the Department's use of the land was temporary. It was contended by the State that the taking was also for a future fish and wildlife management area, a valid purpose of the State Water Project. (The Department transferred use and possession of the borrow area to the State Department of Fish and Game after major construction on Oroville Dam and Reservoir was completed.) A major part of the area subsequently has been included within the designated floodway established by the State Reclamation Board.

Western Pacific Railroad. Another large acquisition of property was 18 miles of new right of way for relocation of the Western Pacific Railroad from the Feather River Canyon to the west of Lake Oroville. Seventy-one parcels of land containing 1,317 acres were acquired at a cost of $824,628. Major severance problems were caused for property owners lying east of a lengthy railroad embankment because access was provided by means of undercrossings that were only 14 feet wide. Butte County later raised its standards to require 28-foot access before any property could be rezoned for higher than agricultural use. It was more economical to negotiate damage settlements than to rebuild and enlarge the undercrossings after the railroad was operating over the new embankment.

Big Bend Powerplant. Acquisition of Pacific Gas and Electric Company's (PG&E) Big Bend Powerplant on the North Fork of the Feather River at Oroville involved not only the State's largest single acquisition at $25 million but also a complicated approach to valuation. The valuation formula was complex because of the need to evaluate monetarily the amount of hydroelectric power output to be lost, the inability to find a substitute hydroelectric power plant location within the State, and the lack of sales of comparable hydroelectric plants. As a result, the valuation was based on the cost of constructing and operating a substitute fossil fuel plant of equivalent capacity. Suitable upward adjustments were made for higher fossil fuel operating expenses over the projected economic life of Big Bend Powerplant. After acquisition, PG&E operated the plant for the State until the plant was inundated by rising Lake Oroville; PG&E purchased the power.

Clifton Court Forebay. Clifton Court Forebay is located in the North San Joaquin Division of the California Aqueduct. This facility required the acquisition of 2,612 acres of land from 15 property owners at a cost of $3,999,690. The initial program included an additional 1,000 acres of recreation lands located on the north and west boundaries of the reservoir. However, public opposition to the recreation proposal resulted in abandonment of these recreation plans.

The remaining land acquisition program was one of some difficulty due to the reluctance of affected landowners to sell. As a result, a condemnation action was filed and orders for possession were served on the property owners to meet scheduled construction but, prior to award of contract, the property owners filed an injunction to set aside the order for possession. This resulted in a hearing and a decision favorable to the State, and all parcels were acquired through negotiated settlements.

Del Valle Dam and Lake Del Valle. Del Valle Reservoir (now known as Lake Del Valle) was added as a feature of the State Water Project in 1958. It is located about 6 miles south of Livermore in southern Alameda County. Its purposes are regulatory storage, flood control, and recreation.

Land acquisition for the dam and reservoir concerned two ownerships. Fee title was acquired for 3,397 acres of the first ownership at a total cost of $1,530,531. A substantial portion of this amount was attributed to the cost of the land required for recreation purposes. From the second ownership, 66 acres of road right of way in fee, together with permanent slope easements, were acquired at a cost of $33,559.

The larger acquisition took 3,397 acres from the middle of a 9,185-acre cattle ranch, one of the largest land holdings in the area. Severance of the property left an easterly remainder of 1,123 acres with neither water nor access. A further problem was caused by severance of the county road. The road through the valley to the ranch was at that time the only access to the ranch as well as to other properties in the area. It was relocated through a valley to the north of Arroyo Del Valle and now serves not only the landowners but also the recreation area for the Project.

In the negotiations, a standby arrangement was made to pay for the relocation of 3 miles of the ranch's existing pipeline, which brought water from a spring. This was an alternative to a less expensive plan for the seller to drill wells on the easterly and westerly remainders. The wells proved to be adequate and the pipeline alternative was abandoned. The damaged access to the westerly remainder required an engineering study to produce cost estimates which were used as the basis of payment to the owner. Damage payments and road relocations, even though substantial, were less expensive than outright purchase of the property.

The Department administers a grazing lease covering about 2,000 acres of the site. This guarantees regular patrolling which reduces fire hazards, as well as producing income to the State.

San Luis Joint-Use Facilities. The San Luis Joint-Use Facilities are used by the State Water Project and the Federal Central Valley Project. San Luis Reservoir, O'Neill Forebay, San Luis Pumping-Generating Plant, Dos Amigos Pumping Plant, and 103 miles of concrete-lined aqueduct extending from O'Neill Forebay south to Kettleman City comprise the major features of the Joint-Use Facilities. In addition, Los Banos and Little Panoche Reservoirs protect the Aqueduct from cross floodflows.

The Department purchased all land required for the reservoir features, while the U. S. Bureau of Reclamation acquired the necessary right of way for the Aqueduct. A total of 31,441 acres of land was acquired by the Department at a cost of $6,357,967. Recreation land accounted for 1,389 acres and surplus land 6,136 acres of this total. The latter figure is large because two ranches were acquired in their entirety. The Bureau of Reclamation constructed the Joint-Use Facilities, and the Department operates and maintains them. Joint-use costs for the reservoir features are divided 55% to the Department and 45% to the Bureau of Reclamation. The State was thus reimbursed for 45% of the land costs. All lands acquired by the State were transferred to the Bureau with the exception of the 6,136 acres of surplus land now under lease. These lands are being studied as to possible use or sale on a program that calls for complete disposition by the end of 1975.

Tejon Ranch. Tejon Ranch, consisting of 271,300 acres, is located in Kern and Los Angeles Counties. Prior to construction of the Aqueduct in this area, involving the crossing of the Tehachapi Mountains, the State filed condemnation suits on a small portion of this land required for construction. When the Department had determined its exact needs for the land, it purchased in fee certain areas, such as sites for surface structures, and compensated the Ranch for permanent easements acquired elsewhere. On the portions of Tejon Ranch property needed for construction operations only, such as borrow and spoil areas, rights of entry were granted to the Department. These covered a large acreage, and Tejon Ranch was compensated for state use based on the length of time the areas were used and the damages incurred.

To avoid severance damages in areas where the Aqueduct crosses parts of the Ranch, farm service bridges were built as part of the construction contracts.

A final settlement of $1,800,000 was made in December 1969. Included in the settlement was interest at 7% (by law) on all fee and permanent easements acquired and on the temporary easements where the land was damaged or had been fenced out of the Tejon Ranch holdings. Interest was paid only for the length of time the State's contractors used the various portions of the property.

The following is a breakdown of the land acquired from Tejon Ranch Company and the rights granted to the State:

1,852 acres purchased in fee
(surface rights only)

854 acres permanent easements

1,143 acres temporary easements

Cedar Springs Dam and Silverwood Lake. This reservoir is located in San Bernardino County in the San Bernardino Mountains near Hesperia. Originally it was conceived to be a 200,000-acre-foot reservoir. However, reservoir size was reduced to approximately 75,000 acre-feet because geological considerations made it prudent to limit the height of the dam. The lake inundated the site of a small settlement called Cedar Springs. The entire town was acquired by the State.

A unique aspect of the Silverwood Lake site was the contention of one of the landowners that he held enough land and water rights to construct and fill a substantial reservoir of his own. The fact that he has successfully drilled a number of horizontal wells which tapped water strata deep inside the mountains was of significance in the settlement of the court case. State monitoring of the springs, streams, and wells showed adequate water to do the development the owner proposed. As a result of these studies, the State paid market value based on the water-oriented recreational development potential of the land, the lake site it contained, and the water supply.

Perris Dam and Lake Perris. This reservoir was originally planned to be of a 100,000-acre-foot capacity. Provisions were made in the design of the dam to enlarge it to provide a capacity of 500,000 acre-feet at any time in the future The Metropolitan Water District (MWD) of Southern California might request the additional capacity. The District is the only water contractor receiving water from this facility and would supply all funds for any increase in size. The MWD finally decided that the reservoir should be increased only slightly, to a permanent gross capacity of 120,000 acre-feet. The design of the dam was modified during construction to provide a gross storage of 131,452 acre-feet. These changes in reservoir capacity and size of dam caused changes in the State's land acquisition program. For instance, the borrow area was originally sized for the ultimate 500,000-acre-foot reservoir, and acquisition was begun. When the acreage for the borrow area was reduced, security deposit funds for the larger area had already been withdrawn by the property owners. A negotiated settlement is in progress.

Projected Savings Through Controlled Acquisitions

The property rights acquired and the schedule for their availability have been managed to realize whatever economies were available in the design, in the establishment of take lines, and by coordinating acquisitions with adjacent projects of other agencies as discussed later. Examples are:

Santa Ana Valley Pipeline. This pipeline extends from Devil Canyon Powerplant, on the southerly slopes of the San Bernardino Mountains, through the cities of San Bernardino and Riverside, to Lake Perris. Wherever possible, pipeline alignment was contained within city streets and flood control channels, which resulted in substantial savings in right-of-way costs. In one section, alignment had to be routed through numerous orange groves, some of which were 80 to 100 years old. Negotiations for purchase of a 100-foot easement corridor through these groves were difficult, but all 28 parcels were acquired without going through condemnation trial.

Negotiations for an easement through Riverside Raceway involved establishing a construction timetable that would not interfere with the automobile racing schedule. To assure this, the easement was acquired early and a separate contract was let for the portion of pipeline through the Raceway prior to construction of the balance of the pipeline. This contract included provision for indemnification of the State and the Raceway if failure to meet the construction deadline necessitated cancellation of a race. The objectives were met successfully.

Coordinated Acquisitions. The North San Joaquin Division of the California Aqueduct required acquisition of 8,924 acres from 210 landowners. This program provided an opportunity for the Division of Highways and the Department of Water Resources to coordinate their land acquisition programs where Interstate 5 and the California Aqueduct were to be built parallel to each other for 53 miles south of Tracy. In many cases, the needs of both agencies would involve acquisitions from the same property owner. Coordinated acquisitions could provide lands and rights of way in the most economical manner with the least inconvenience to affected property owners.

The Department and the Division of Highways entered into a contractual arrangement whereby the Department utilized services of the Division of Highways for project purposes. It was agreed that the Department would advance funds to Highways for direct payments to property owners and for the expenses of acquisition.

The Peripheral Canal and Interstate 5 provided a similar opportunity for economy because their alignments parallel each other for 13 miles north of Stockton in San Joaquin and Sacramento Counties. Under interagency agreement, Highways used approximately $2.7 million of its money for performance of all activities necessary to acquire the right of way for the Peripheral Canal in the joint area. The money will be repaid to Highways as canal construction starts, or not later than an agreed date. The Division of Highways under this program will be able to excavate within the proposed canal prism the material needed as fill for construction of the freeway at much less cost than obtaining fill from alternative sources. In addition to this saving, the impact on the environment of excavating from alternative sources is greatly reduced.

Claims of Damage to Property Values

Claims submitted to the State Board of Control and inverse condemnation suits by landowners contend that there is a reduced land value due to alleged erosion and seepage along the Feather River and adjacent to Thermalito Afterbay, caused by the operation of the Project. It may be several years before these matters are resolved.

Disposal of Excess Lands

Scope of Program

Pieces of land acquired but remaining after department needs were met totaled 926 parcels. Most of these were acquired as alternatives to paying for severance damage which would have been more expensive. A number of parcels were declared excess due to design changes after acquisition. Some spoil and borrow areas became excess after their use for project purposes was completed.

Approximately 85% of the parcels, a majority of which were located in rural areas, were landlocked. Many were small and irregular in shape. They varied in size from 0.001 of an acre to 4,000 acres. Utilities were available for only a small percentage.

The following list shows the location of the excess parcels by Division:

Division	Parcels
Oroville	185
South Bay Aqueduct	24
North San Joaquin	63
San Luis	5
South San Joaquin	170
Coastal Branch	16
West Branch	4
Mojave	425
Santa Ana	34
Total	926

Standard Procedures

The program for disposal of excess lands reduced the parcels remaining from 926 to 318 by June 30, 1974. By 1976, all backlog is scheduled to be eliminated, and the only excess parcels will be those resulting from current design and construction programs.

The steps of the disposal procedures are:

1. Identification of excess parcels
2. Clearance by Department of Water Resources' units
3. Clearance by state and local agencies
4. Appraisal
5. Property survey report preparation
6. Environmental impact review
7. "For Sale" sign placement
8. Preparation of sale brochure
9. Advertising
10. Bid opening
11. Sale document processing
12. Document recording

Special Situations

Borrow Areas. Impervious clay material for the core of Cedar Springs Dam was taken from a dry lake in the vicinity of Apple Valley 15 miles away. The 80-acre bowl thus created constituted a lakebed which could be fed from a well on the property. This property has been sold, but a somewhat similar 500-acre area near Perris Dam is being studied to determine its potential for wildfowl habitat before a decision is made as to disposition.

Spoil Areas. Sales of material by the yard are being made from several construction spoil areas, thus enhancing total disposal revenues. Others have been sold as grazing land, for example, near Delta Pumping Plant and Clifton Court Forebay, because there is no local demand on a yardage basis for the type of material available at these locations.

Sales to Public Agencies. The transfer of Thermalito Forebay to the Feather River Recreation and Park District is an example of a sale of state-owned land to a local agency. State statutes give first opportunity to state departments and local recreation agencies to buy excess land. The Department of Water Resources has cooperated in such transactions by offering payment plans in accord with the budget schedule of the buyer.

Property Management

Extent of Operating Properties

There are 642 miles of aqueduct right of way and 491 miles of reservoir shoreline for facilities completed. When the Peripheral Canal in the Sacramento-San Joaquin Delta is completed, aqueduct right of way will total 685 miles. Operating properties will continue to increase as some of the projects now in the planning stage, such as the North Bay Aqueduct and the Coastal Branch Aqueduct, become realities.

Shared Use

There are frequent requests to share occupancy of the Department's right of way. These come from utility companies, oil companies, land developers, ranchers, and others who wish to construct something or who desire access for specific purposes in connection with their facilities or other business in the area.

Such rights may be requested to be granted in the form of an Easement Deed, Encroachment Permit, License for Common Use, or Joint Use Agreement. Upon receiving a request, the right of occupancy is granted, denied, or negotiated into an acceptable form.

An applicant for a right to install a facility over the Aqueduct seldom has any convenient alternate route for passage from one side to the other, and usually the inconvenience to the Department is inconsequential. Rights are normally granted after assurance that disruption of state facilities will be minimal and that there is no increase in potential liability.

As another general policy, requests for longitudinal sharing of the right of way are discouraged because of increased costs of maintenance of operating roads, liability, and effect on project operations. In some cases, the Department has been obliged to allow such use. Some of these obligations were anticipated and provided for by agreements to alleviate severance damages when the Department acquired the right of way.

Housing Development

Following an economic study which revealed a scarcity of housing available to department employees prior to commencement of Oroville Dam construction in 1961, a 70-lot housing subdivision outside the City of Oroville was designed and developed by the Department. Arrangements were made for sewer facility extensions, water service, and electric and gas service. Extension of utilities to the subdivision benefited intervening undeveloped areas.

Upon completion of the Oroville housing complex, disposal of vacant lots and 55 houses was undertaken to return the property to local tax rolls. The houses were sold as a package to the highest bidder on a wholesale basis. An economic analysis had indicated that wholesaling was preferable due to the probable length of time required for retail disposal as a result of the saturated housing market at the time. The remaining vacant lots were sold to the public on the basis of bids at amounts which recovered approximate development costs.

Leases

Upper Feather Division. Two parcels of land were leased for grazing purposes in the Frenchman Reservoir area subsequent to acquisition for project purposes. The most significant lease was to the original property owner. The area contained 2,055 acres at a rental value of $1,600 per year. The last lease on this property was terminated in May 1969.

Three grazing leases were executed on those lands adjacent to or inundated by Lake Davis. The Department's lease program in the area will terminate when the remaining property is transferred to the U. S. Forest Service under a federal-state land exchange, probably in 1975.

Oroville Division. Land acquired for Oroville Reservoir was first placed under interim lease in 1960. During the period of acquisition, construction, completion of Oroville Dam, and filling of the reservoir, 32 leases were executed.

San Luis Joint-Use Facilities. This area includes San Luis Reservoir, O'Neill Forebay, San Luis Aqueduct, and what was formerly the Delta-Mendota soils test site. Portions of the above areas have been involved in a leasing program which originally covered approximately 17,270 acres of land. The breakdown is as follows:

San Luis Aqueduct	287 acres
San Luis Reservoir and O'Neill Forebay	16,750 acres
Delta-Mendota test site	233 acres

Some of these lands were owned by the Bureau of Reclamation but, by agreement, the Department became the lease operator.

One of the largest and most complex leases in the San Luis area covered a large portion of the lands in and around San Luis Reservoir. The 16,300 acres were purchased by the Department in 1960, and the entire holding was then leased at a semiannual rental payment of $21,875.

In 1961, the Bureau of Reclamation commenced preconstruction activities on O'Neill Forebay and San Luis Dam and, in 1962, construction of these facilities began. At the same time, Division of Highways' contractors began work on relocation of State Highway 152. These activities were, of course, anticipated in the interim leasing program. The area under lease was reduced as land was needed for its primary purposes. The unused land now consists of 6,136 acres and is currently under lease for $25,000 per year.

Leasing and Sales—Financial. As of July 1974, the Department has realized gross receipts of $7,724,000 from property rentals and sales. Because decisions as to the best disposition of property take time, the lease programs have been valuable in the interim—producing revenue and providing property protection. Leases prove to be the best way of obtaining continuous patrolling and protection of property that could otherwise have suffered fires, vandalism, and tree cutting.

Recreation and Environmental Aspects

Recreation Land Planning

The Davis-Dolwig Act, passed by the Legislature in 1961, declares that recreation and the enhancement of fish and wildlife resources are among the purposes of state water projects. Prior to 1959, the Department had established programs for recreation and fish and wildlife planning of the State Water Project. Initially, Project Funds were used to finance studies leading to completion of land use and acquisition plans (Preland Programs) which, when approved, authorized acquisition. Later programs used General Funds (developed from the general tax of the State) and carried the studies from land use and acquisition plans through to their completion—usually recreation development plans (Postland Programs). Land acquisition for recreation purposes is reimbursed under a 1966 amendment to the Davis-Dolwig Act which allocates up to $5 million annually of the State's oil and gas revenues to repayment of Legislature-approved recreation costs. These funds cannot be used for actual onshore recreation facilities.

The present program was started in July 1972 and contains the activities formerly included in the Preland and Postland Programs. In 1972, emphasis was increased on implementation of recreation and fish and wildlife plans and on visitor facility planning, which resulted in minor additional land acquisition.

Federal Support

HUD and BOR. Various federal agencies were requested to participate in the recreation and environmental aspects of the State Water Project. The Federal Department of Housing and Urban Development (HUD) and Bureau of Outdoor Recreation (BOR) have paid approximately $1,600,000 as a contribution to preservation of open space at Castaic, Silverwood, and Perris reservoirs.

U. S. Forest Service. Memoranda of Understanding between the U. S. Forest Service and the Department were developed to cover federal lands encompassed in the various reservoirs. These Memoranda supplemented Special Use Permits issued by the U. S. Forest Service to cover department activities on federal land. Under the Memoranda, the Department provided fire plans, clearing and cleanup, protection of lands and resources, replacement of existing facilities, construction of new roads, road maintenance during construction, land acquisition, recreation, schedules of construction and operation, and safeguards against stream pollution. In addition, the Memoranda provided for development of postconstruction operating plans by the various concerned parties.

Land Exchanges

U.S. Forest Service. Water Code Section 11915.5 provides "For the purpose of furthering recreation in any project of the department, the department may exchange any real property it has acquired for property in the state owned by the United States which is of substantially equal value, whether or not such real property of United States is adjacent to or needed for any project of the department." This section further states "Any such exchange involving real property acquired by the department solely for recreation shall be concurred in by the Department of Parks and Recreation." If property acquired by exchange is placed under jurisdiction of the Department of Parks and Recreation, the funds to reimburse the Department of Water Resources are obtained from oil and gas revenues as authorized by the Davis-Dolwig Act.

Department acquisitions of substantial recreation lands at the three Upper Feather River reservoirs and at Silverwood Lake were involved in a series of exchanges resulting from the aforementioned legislation. In these transactions, recreation responsibility at the Upper Feather River reservoirs passed from the Department to the U.S. Forest Service. In return, the State acquired either lands or land rights in other areas of California. In one exchange the State acquired 2,100 acres of federally owned land at Squaw Valley, the site of the 1964 Winter Olympic Games, and additional land adjacent to Plumas-Eureka State Park. In return, the Department of Water Resources gave up 7,474 acres around the Upper Feather River reservoirs. This exchange was made possible when the Department of Parks and Recreation concurred in the use of Davis-Dolwig funds to compensate the Department of Water Resources for the lands it gave up.

The advantages of this land exchange were: (1) it removed the U.S. Forest Service from complex negotiations the State was conducting with concessionaires at Squaw Valley, (2) it rounded out the State's holdings at Plumas-Eureka State Park, and (3) it ended state recreational management responsibility at the Upper Feather River reservoirs.

East Bay Regional Park District. Lake Del Valle, located within an hour's drive of the metropolitan San Francisco Bay area, offers valuable water-oriented recreation. The Lake's entire 3,500 acres are devoted to recreation, except for the areas necessary for operation of the dam. The Department of Water Resources has transferred recreation rights to the Department of Parks and Recreation. In turn, Parks and Recreation has an operating agreement which provides for recreation facilities to be operated by the East Bay Regional Park District. The Park District has authority to contract with private concessionaires for recreational facilities at the Lake.

Federal Power Commission Licenses

Federal statutes require that licenses be secured from the Federal Power Commission for projects which have power-generating aspects or obstruct navigable streams. Oroville Reservoir is covered by FPC License No. 2100. Various reservoirs, aqueduct reaches, and power facilities in the southern part of the State Water Project are to be covered by License No. 2426, for which the Presiding Examiner's initial decision was issued on January 14, 1972. The date when this license will be issued is not known.

The FPC statutes give priority to power development over other uses of federal land and thus provide a basis for obtaining rights in areas such as national forests. FPC establishes close control over land in the project area, whether originally federal or private, and thus land management, disposal, development for recreation purposes, and all other uses require careful documentation to obtain FPC approval.

CHAPTER III. RELOCATIONS

General Policy

The Department of Water Resources' basic policy regarding utilities, common carriers, roads, and plants affected by the construction of the State Water Project allows for any of the following alternatives:

1. To provide substitute facilities equal in usefulness and life to the existing facilities as required by Section 11590 of the Water Code;
2. To negotiate agreements for abandonment if the cost of relocation exceeds the value of the facility, or if the facility is no longer needed due to the Project;
3. To allow the owner to increase capacity or durability of the facility, provided the owner pays the difference in cost between replacement in kind and the improved facility; and
4. To provide footings, piers, or abutments for planned enlargement of facilities at a future date by the owners.

The Department developed a policy of encouraging owners to perform their own relocations, including design and construction, subject to review and approval by the Department. Where the relocation required design or construction that was beyond the capabilities of the owner, either the Department designed and constructed the facility, subject to approval of the owner, or the owner retained a consultant for design and awarded the construction to a contractor in accordance with the terms of a relocation agreement. With the exception of state highways, railroads at Oroville, and Los Angeles and San Bernardino county roads, the Department designed and constructed all other related facilities. The Department owns all support facilities within the water prism of aqueducts it built. In the joint facilities area, it is a co-owner of the land and, as sole manager, it handles these relocated facilities as it does those elsewhere along the Project.

Overall Cost

The total cost of the relocations program for the entire Project was approximately $160,000,000 for some 1,385 relocations, large and small. About 60% of this amount was paid to the owners of affected facilities to accomplish the relocation either in advance of work on the Project or, where necessary, in cooperation with the State's contractor on the Project. The remaining 40% of the work was by state contract under the direction of the Department.

Relocations for Reservoirs

Relocations were sometimes quite extensive, particularly where reservoirs inundated large areas of land. Some service areas were decreased substantially and, in some cases, to such degree that the utility was abandoned completely. In the Department's reservoir relocations, two types of problems were usually created: (1) moving a facility from the floor of the valley to a hillside presented new maintenance problems to the owner, particularly in the case of road relocations; and (2) relocations around a reservoir caused conflicts with other facilities by creating areas of common use that did not exist previously. Each area of common use then required an agreement between owners detailing how they would cooperate with each other regarding maintenance or replacement of facilities.

Upper Feather River

Relocations in the three Upper Feather River reservoirs constructed to date consist solely of U.S. Forest Service roads. Roads in the reservoir area were rerouted around the reservoirs and across the tops of the dams. These were handled as part of the land acquisition and were constructed under the prime contract for the dams. Costs of these roads were included in the construction of the dams and were not accounted for as part of the relocation programs.

Oroville (Figure 11)

Western Pacific Railroad around Lake Oroville was the largest single relocation in the State Water Project. Over 18 miles of track were relocated from the Feather River Canyon to the west in the period from 1959 to 1963. To maintain a maximum grade of 1%, the relocation was started one-half mile below Thermalito Diversion Dam and ended in the Feather River Canyon one-half mile beyond the backwater of Oroville Reservoir at normal pool. The relocation involved the construction of five tunnels and three bridges at a cost of approximately $40,000,000. The tunnels, bridges, and roadbed were constructed under six separate state contracts, in accordance with department design, and the ballast and tracks were laid by the Western Pacific Railroad at state expense. The route of the new railroad crossed existing utilities at 26 points. These utilities were relocated under 19 agreements with individual owners at a cost of approximately $500,000.

Twenty-one miles of U.S. Highway 40a (now State Highway 70) generally paralleled the Western Pacific Railroad through the Feather River Canyon. In the period 1957–63, it was reconstructed to the west of the new railroad right of way at a cost of $15,000,000.

Three bridges were built for the highway relocation: one across the Feather River below Oroville Dam, another across the Project's Thermalito Power Canal (Figure 12), and the double-deck highway-rail-

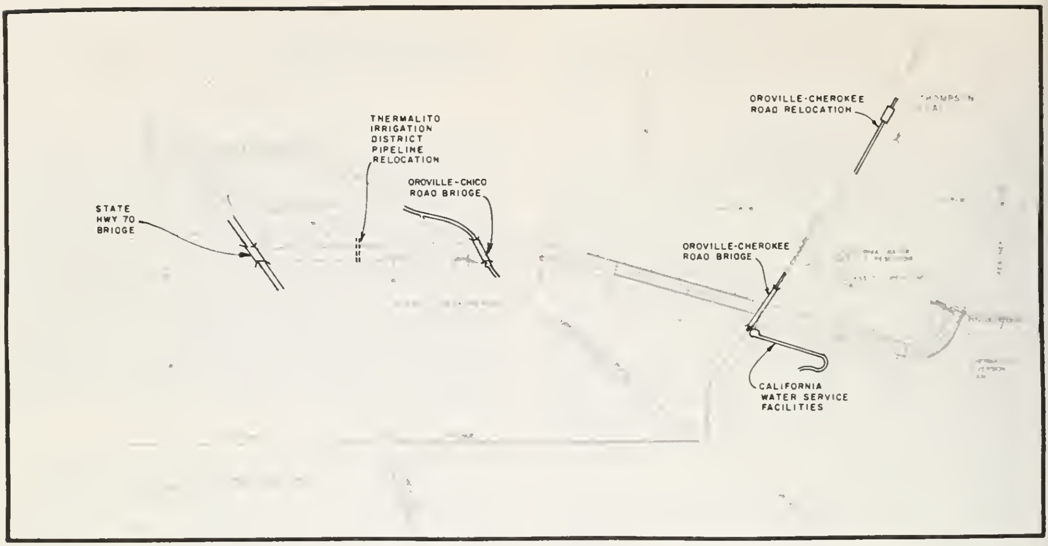


Figure 11. Oroville

road bridge across the West Branch arm of Lake Oroville.The Division of Highways of the Department of Public Works (now the Department of Transportation) paid for 25% of the new four-lane freeway portion between Oroville and the Chico turnoff as the incremental cost between replacement of the previous two-lane highway and the improved facility. Relocations of utilities crossed by the new highway were negotiated by the Division of Highways, and the costs were borne by the Department of Water Resources through an interagency agreement.

The Feather River Railway connecting the sawmill at the foothill community of Feather Falls to a transfer shipping point at Oroville was a common carrier, operating in the area inundated by Lake Oroville, consisting of approximately 18 miles of track, land rights, and appurtenances. The Georgia-Pacific Corporation, which owned the railroad, originally had demanded that the State replace and relocate the railroad at a cost close to $9,000,000. The California Public Utilities Commission had decided in favor of the Corporation and ordered the Department to relocate the line. After the decision was handed down, it was discovered that the Corporation was a trespasser on federally owned land due to the expiration of a 25-year lease on land that had been withdrawn for power development. The proceedings were then settled by written agreement between the parties. In the agreement, the Georgia Pacific Corporation rescinded its early demand and agreed to accept $1,322,605 for its 18 miles of line and to substitute truck carrier service for the abandoned railway. A portion of the money paid to the Corporation was used to improve public roads and to provide private road facilities where necessary between the community of Feather Falls and the sawmills and connecting transportation at Oroville—the former terminus of the railroad.

Two major county road relocations were required —Oroville-Quincy and Oroville-Feather Falls—and several lesser road modifications were made. The Oroville-Quincy Road formerly entered the reservoir area at the location of Bidwell Canyon Saddle Dam, crossed the Feather River at Bidwell Bar over a newer bridge downstream of the old suspension bridge, and proceeded northerly through a small arm of the reservoir to Quincy. To relocate it, two bridges were constructed across the reservoir, one at Bidwell Canyon and the other at Canyon Creek. The Oroville-Feather Falls Road was relocated about 1 mile east of its original location and bridged across the South Fork arm of the reservoir.

There were five major utility relocations at the reservoir. These included: (1) Western Union's telegraph line that paralleled the Western Pacific Railroad through the Feather River Canyon, which was rerouted around the reservoir along the relocated railroad right of way; (2) the easterly portion of Pacific Gas and Electric Company's (PG&E) east-west 44-kV power line, which was rerouted north of the South Fork to a narrow crossing of the reservoir, then along the south side of the South Fork of the Oroville-Quincy Road and tied into the existing lines to the north and south of Bidwell Canyon bridge. The westerly portion of this line was stubbed off in the Lime

Saddle recreation area; (3) the north-south telephone line, which was replaced by a microwave relay across the reservoir. The south reflector was placed adjacent to the Bidwell Canyon Saddle Dam, and the north one was located between the Oroville-Quincy Road and the Western Pacific tracks; (4) the Division of Forestry's telephone line, which was included on the Pacific Telephone microwave relay; and (5) a portion of the Oroville-Wyandotte Irrigation District's Palermo Canal inundated by the reservoir was abandoned, and an outlet was constructed through the Oroville Dam left abutment to supply water to the downstream portion of the Canal.

Graves in cemeteries containing private burial plots in the reservoir area were relocated to a state-constructed cemetery next to the existing Pioneer Cemetery, just north of the Thermalito Power Canal adjacent to the Feather River.

Bidwell Bar artifacts have been moved to temporary locations near Oroville until permanent sites can be developed. The old suspension bridge and tollhouse (see Chapter X, Archeology) are stored at a site near Oroville pending reconstruction, and the Mother Orange Tree is being maintained in a controlled environment near the Department's Operation and Maintenance Center at Oroville.

Thermalito Complex

Thermalito Power Canal (Figure 12). Two high-level bridges were built at Oroville-Cherokee and Oroville-Chico Roads. Provisions were made to carry existing and future utilities through the diaphragms in the box girders and inside the curbs of the bridges. Power lines span the Canal, while pipelines and telephone cables are carried across the Canal inside the box girders and curbs.

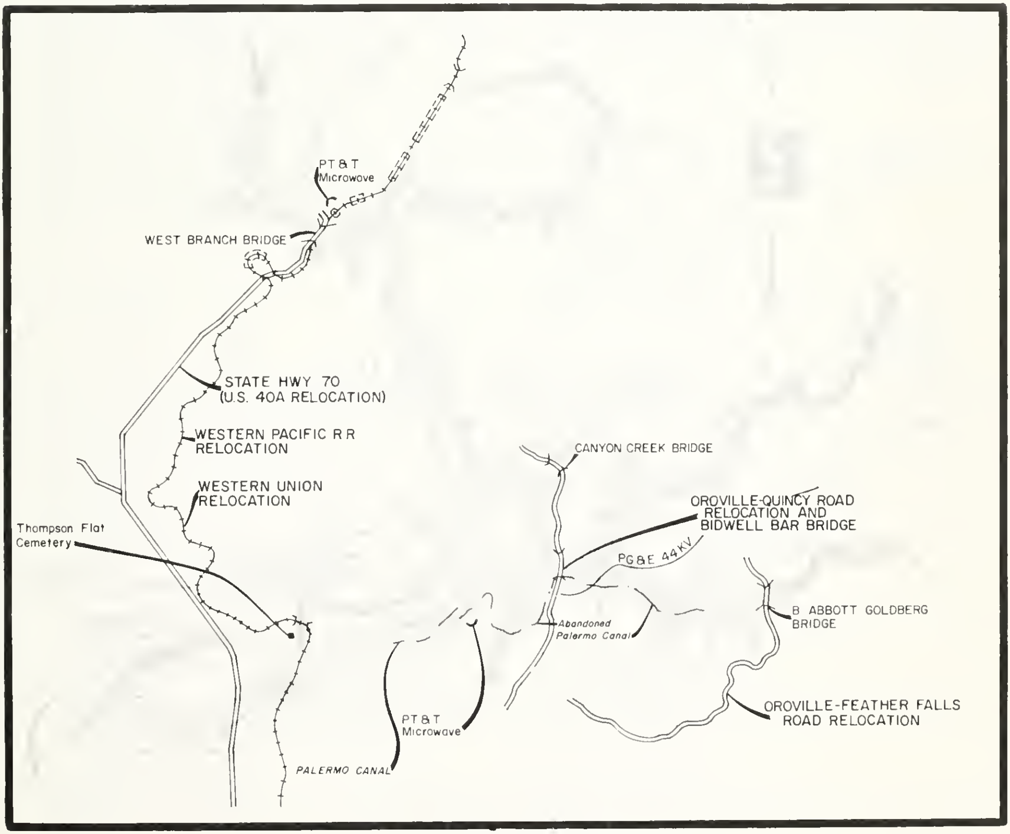


Figure 12. Thermalito Power Canal

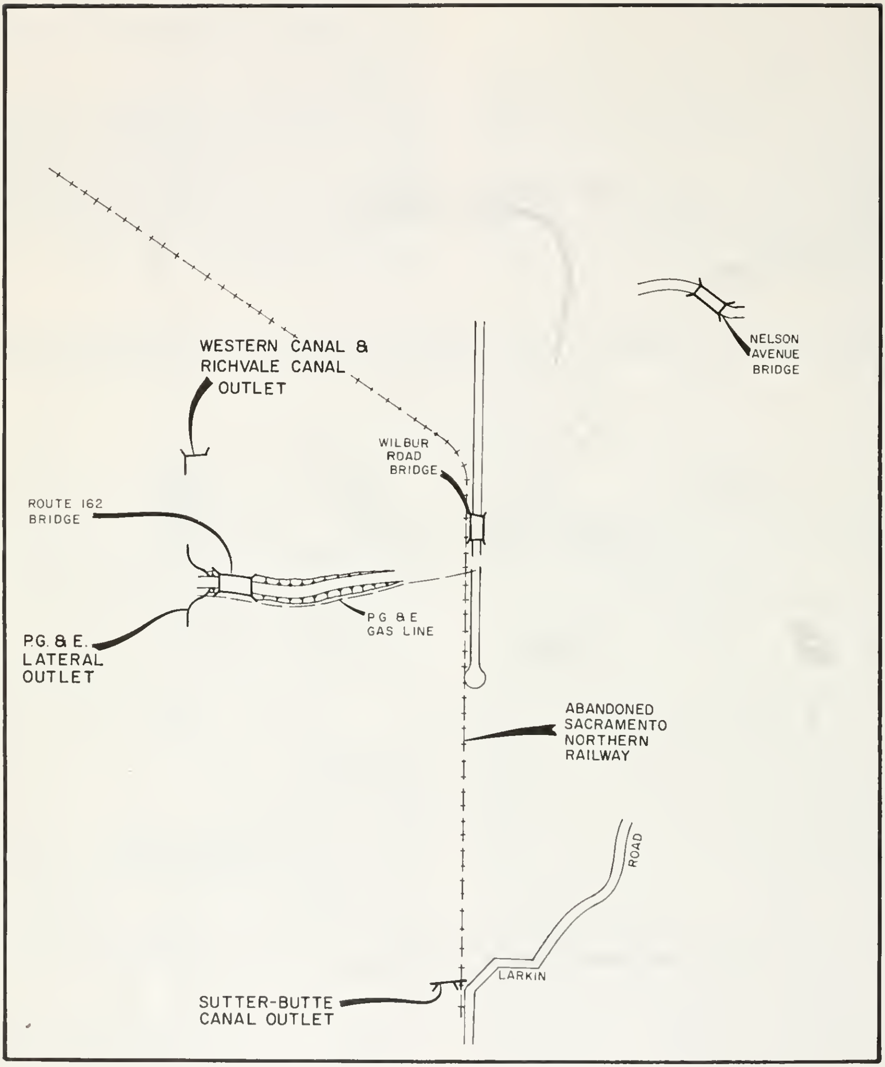


Figure 13. Thermalito Forebay and Afterbay

A 24-inch-diameter water pipe east of the State Highway 70 bridge crosses the Canal supported by two piers at the edges of the base of the Canal. The bridge was constructed by the Division of Highways as part of the highway relocation around Lake Oroville.

At its deepest point, the Thermalito Power Canal cuts across what was the most critical part of the alum water treatment plant for the City of Oroville's water supply. Since the treatment plant design had proven satisfactory, it was decided to duplicate the existing plant as closely as possible. Water is now carried across the Canal by a 39-inch-diameter pipe to the relocated alum feeder. The redwood mixing flume is duplicated, the grade and length are the same as the original, and the length of shotcrete-lined ditch taken by the construction of the Canal is replaced by a loop southeast of the Oroville-Cherokee Bridge.

Thermalito Forebay and Afterbay (Figure 13). County roads to be inundated were rerouted along the shoreline to connect with other roads or terminated with cul-de-sacs. Bridges were built for two county roads: Nelson Avenue at the narrowest part of the Forebay, and Larkin Road where it crosses the tail channel.

State Route 162, which crosses the northerly part of the Afterbay, was placed on both fill and bridge sections. The length of the bridge was such that hydraulic losses due to water flowing north and south would be negligible. Provision was made in the design of the dam embankment for a cloverleaf to be constructed at the intersection of State Route 162 and U.S. Highway 99 at a later date.

The PG&E gas line and the Pacific Telephone cable along State Route 162 were relocated adjacent to the new roadway under an agreement between the utilities and the Division of Highways.

Utilities servicing the area to be inundated were modified to feed from a different direction where necessary. These utilities were PG&E power lines and telephone lines belonging to Pacific Telephone.

The Sacramento Northern Railway through the Afterbay was purchased by the State and removed. Western Pacific, the parent company, was compensated both for the trackage and for the cost of gaining access to the track remaining north and south of the Afterbay by way of Southern Pacific facilities.

Irrigation canals belonging to PG&E, Richvale Irrigation District, and Sutter Buttes Irrigation District, all of which carried water from the Feather River through the Thermalito Afterbay area, were replaced by outlets through the afterbay embankment. The two existing diversion dams on the Feather River, one belonging to PG&E and the other to Sutter Buttes Irrigation District, were removed.

Del Valle (Figure 14)

In the 1963–67 period, two major relocations cleared this site and the dam creating Lake Del Valle was built.

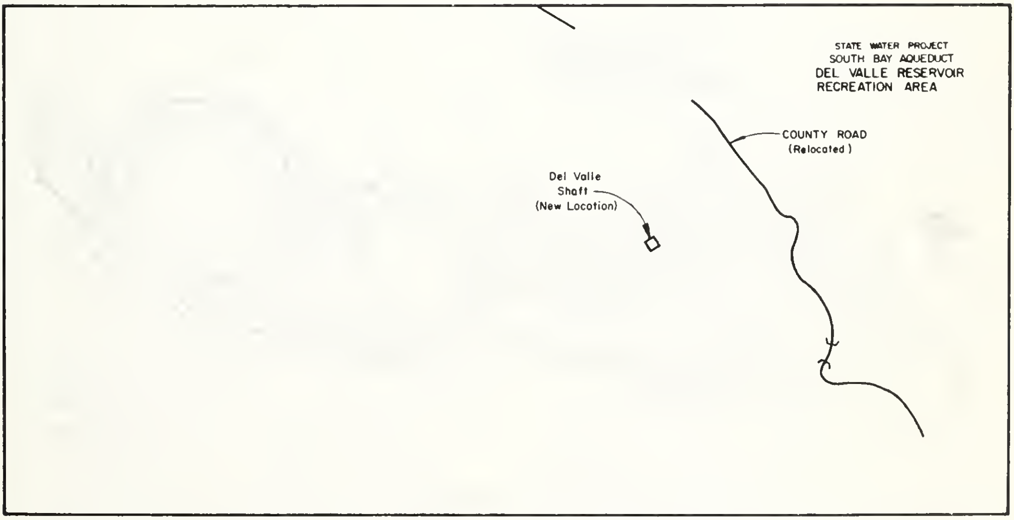


Figure 14. Del Valle

The county road that formerly ran through the inundated area was rerouted and became a scenic highway coming into the reservoir from the east. For access to a recreation area and other property upstream of the backwater of the Lake, a bridge across Del Valle Creek was constructed at the southerly end of the relocated county road. The county owns and maintains the road and the bridge superstructure. The Department of Water Resources owns and maintains the substructure, and East Bay Regional Park District owns and maintains the road beyond the bridge.

The Del Valle shaft, owned by the City and County of San Francisco, was an access to the existing Hetch Hetchy aqueduct tunnel under the reservoir site and was intended to be used as construction access to a new tunnel to be built in the 1980s. By court stipulation, the Department purchased the shaft for the estimated amount required to construct another access shaft outside of the reservoir area and agreed to provide an alternate site for a new shaft when required. The existing shaft was sealed and filled prior to the start of storage in Lake Del Valle.

San Luis (Figure 15)

The rerouting of State Highway 152 around the north shore of San Luis Reservoir was one of the largest highway relocations of the State Water Project. The Division of Highways delayed its planned expansion of State Highway 152 on existing alignment so that the funds could be applied to the portion relocated around the Reservoir, with the work starting in 1963 and being completed in 1965. The Department and the U.S. Bureau of Reclamation divided 55%-45% the difference in cost between constructing the expressway in the valley on the original alignment and on the hillside relocation. It was estimated that the expansion along the original route would have cost $6 million. The final cost on the new route was $18 million. There were no other relocations in the area; however, PG&E abandoned an unused right of way through the Reservoir.

Cedar Springs (Figure 16)

The major relocations in this area were completed in 1969 under a series of agreements, the first of which was dated 1963.

State Highway 138 through the reservoir area was relocated to the west and south of Silverwood Lake (as the reservoir is now named). In anticipation of greatly increased traffic due to recreation at the Lake, grading

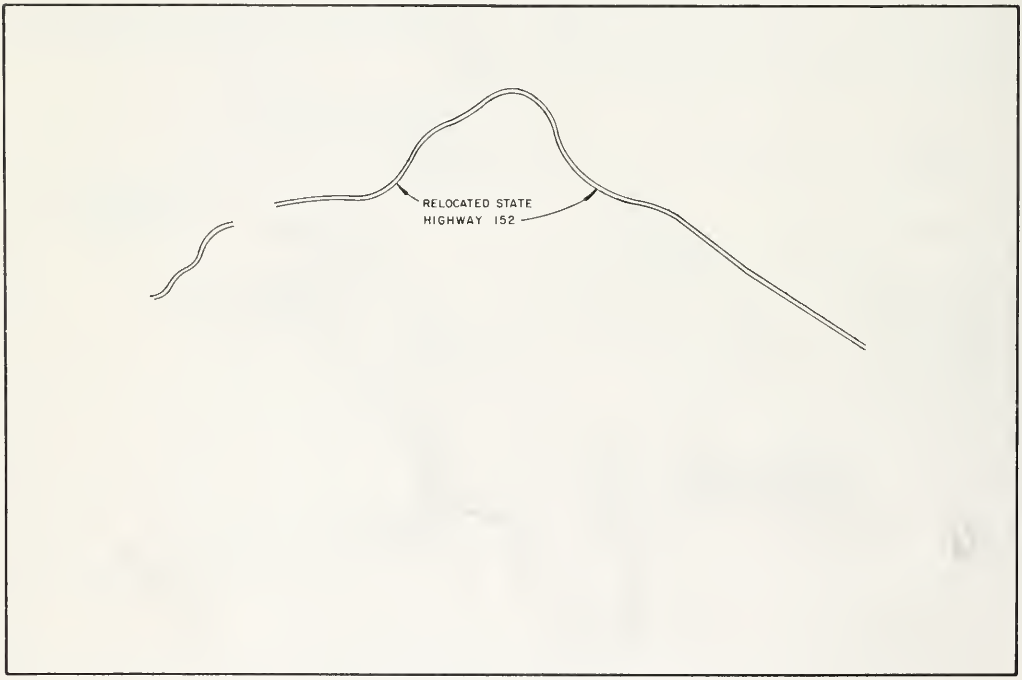


Figure 15. San Luis

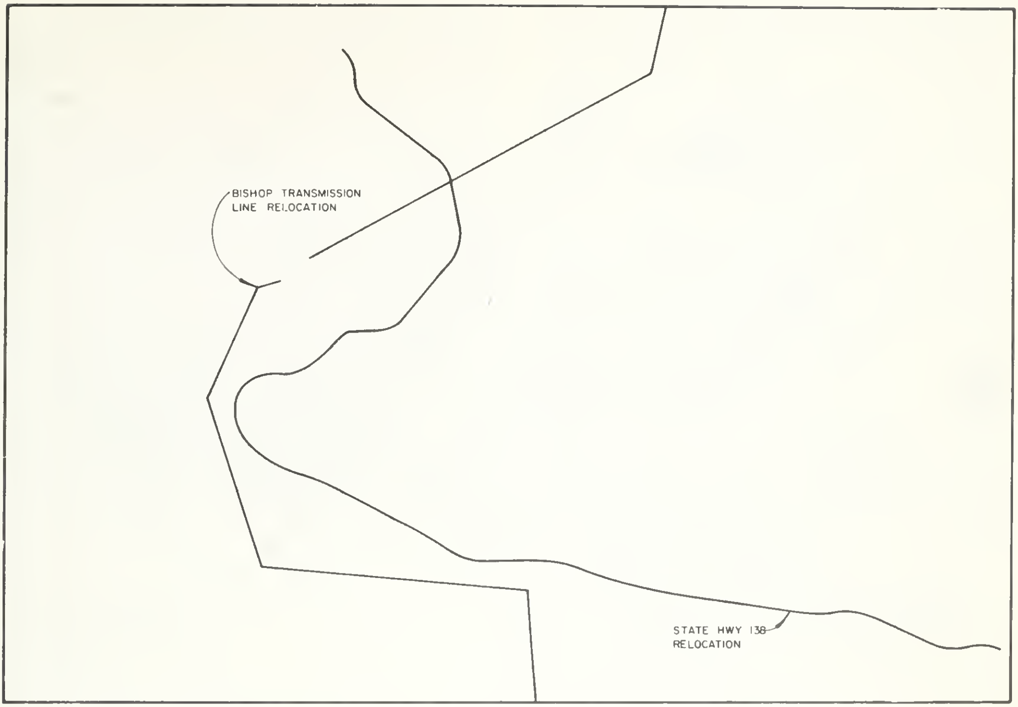


Figure 16. Cedar Springs

was done for a four-lane road but only two lanes were paved. The Division of Highways paid the difference between the cost of replacement in kind of a two-lane road with a four-lane grading with only two lanes paved. The additional work added about 20% to the total cost of the relocation. An interchange for access to Cleghorn Road and a recreation area was constructed at the western extremity of this relocation. A minor relocation was necessary to reroute State Highway 173 away from the downstream toe of Cedar Springs Dam.

Southern California Edison's Bishop transmission line, a major source of power for the Los Angeles area, was relocated from the reservoir area through the hills to the west and south of the new State Highway 138 to avoid recreation areas around the Lake. The other major transmission facility, Edison's Hoover Line, was modified in place by relocating towers to ground above the dam crest. In addition to the transmission line, an access road for maintenance was constructed for the entire length of the relocation.

Utilities serving the inundated area were cut back, and ties were made between existing lines outside of the project area where necessary. These consisted of power lines, telephone lines, and a water line to Las Flores Ranch. The latter is discussed in Volume III of this bulletin. New utilities were installed underground to meet the needs of recreation developments.

Perris (Figure 17)

There were two major relocations at Lake Perris. A county road and a Southern California Edison transmission line were relocated from the reservoir area to the south of the hills surrounding the Lake. Minor relocations involved cutbacks and rearrangement of power and telephone service lines.

Pyramid (Figure 18)

During the early 1920s, the Federal Government allowed power companies to reserve federally owned land for future power generating sites. Many power companies filed applications for these reservation rights, but only a small percentage were approved.

The Pyramid Lake site in the federally owned Angeles and Los Padres National Forests was originally withdrawn for power purposes by an application of the Sespe Light and Power Company filed in 1921 with the Federal Power Commission (FPC). This application was denied without prejudice in 1928, but the withdrawal was never vacated. Since that date, the FPC has required that any utility easements on the withdrawn federal land have a provision requiring the utility to relocate its line at its own expense if the land is needed for power purposes.

Due to the prior withdrawal of land for power development, the FPC refused to allow the new interstate highway to be constructed in a location where it would interfere with the State Water Project. Interstate 5 was then routed out of the canyon to the east of old U. S. 99 to avoid the planned Pyramid Lake; however, that result was not completely achieved. When Pyramid Lake is filled to its capacity of 171,196 acre-feet, the toes of three of the fills for the new highway become inundated. Therefore, the Department contracted to have the fills at Liebre and West Fork Liebre Canyons buttressed by additional fill material and a coat of riprap up to benches at elevation 2,600 feet (6 feet below the dam crest). The bench at the maintenance station at the upper end of the reservoir was set at elevation 2,620 feet to obtain the weight of additional material necessary to buttress the highway fill at that point.

Five companies maintained gas and oil pipelines across the Pyramid Lake site under federal easements with relocation provisions. Those companies were Mobil Oil Company, Atlantic-Richfield Oil Company, Cuyama Pipeline Company, Southern California Gas Company, and Pacific Lighting Service Company. The Department notified them by letter in 1968 of their obligations to relocate their facilities at their own expense.

Southern California Edison Company maintained its Violin Canyon transmission line across the Pyramid Lake site under a 50-year Special Use Permit from the U. S. Forest Service. The Special Use Permit expired by its own terms in September 1969. Edison applied to the Forest Service for an additional 50-year term. The request was denied by the Forest Service on the ground that the Department's power withdrawal pursuant to its application to the Federal Power Commission for a license took precedence over renewals of Special Use Permits. The line was abandoned in place

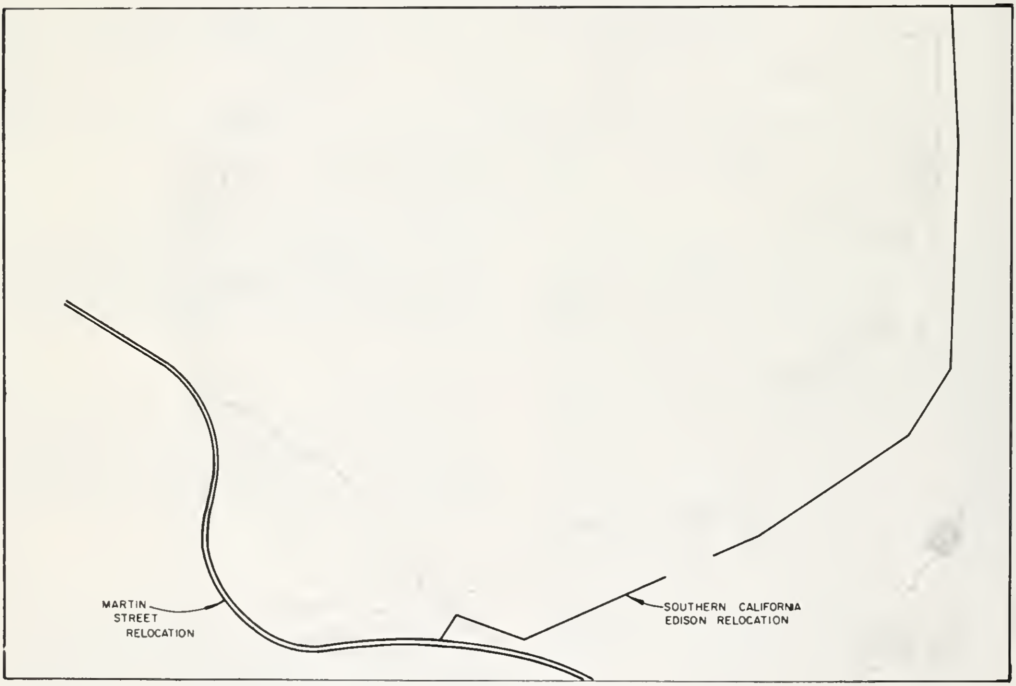


Figure 17. Perris

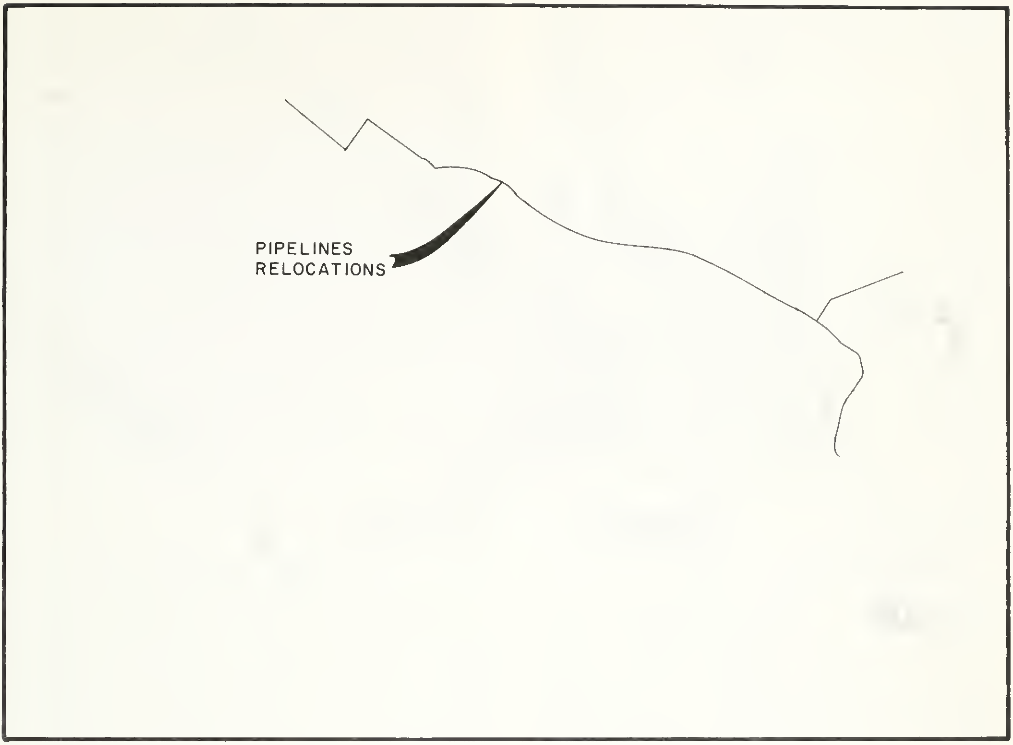


Figure 18. Pyramid

and the Department paid for clearing the site of Edison's facilities. The function of the abandoned line was absorbed by other parts of Edison's transmission system.

To protect their rights, all of the above-named oil companies and Edison filed motions with the Federal Power Commission to intervene in the Department's FPC license application. The motions were granted. Edison later withdrew its intervention concerning the Violin Canyon line after reaching agreement with the Department.

The Federal Power Commission examiner who heard the case rendered his decision on January 14, 1972. The examiner concluded that the licenses were subject to relocation at the expense of owners except for the case of the lines owned by Atlantic-Richfield and its subsidiary, Cuyama Pipeline Company. These lines likewise had to be relocated at the expense of the owner, but the Department was obligated to compensate the owner for the value of the lines. The Richfield 14-inch, light-viscosity, oil line and the Cuyama 10-inch gas line were moved from the inundated area east of the highway fill to the bench on the reservoir side.

The various utilities and oil companies involved have objected to the examiner's decision, and the matter is pending at the present time before the Federal Power Commission itself, along with the overall licensing of the Project. To allow construction to proceed, the Department in 1973 entered into agreements with the various companies for relocation whereby the Department would pay for relocations, retaining the right, however, to recover costs plus interest should the FPC rule in favor of the Department at a later date.

The Mobil Oil Company's 10-inch, light-viscosity line was rerouted around the dam to the east and entered a utility corridor crossing the benches formed by the buttresses for the highway fill just south of West Fork Liebre Canyon. The 22-inch and 26-inch natural gas lines belonging to Southern California Gas and Pacific Lighting Service Companies were combined into a single 22-inch line through the same corridor.

Castaic (Figure 19)

The county road through Elizabeth Lake Canyon was replaced by Lake Hughes Road through the rugged terrain east of Castaic Lake. This relocation required a bridge across Castaic Creek south of Castaic Dam.

The Warm Springs Road relocation at the north end of the reservoir in Castaic Valley serves five purposes: (1) replacement of the abandoned Castaic Creek Road; (2) recreation access to the north end of Castaic Valley; (3) keeping intact the fire patrol road loop between the west end of Fish Canyon Road and the "Old Ridge Route", which intersects Lake Hughes Road, which in turn connects to the east end of Fish Canyon Road; (4) acting as operational access for department personnel between Pyramid and Castaic Dams; and (5) access for equipment to construct and maintain Castaic Powerplant. A two-lane road with sufficient turning radii and proper grades would have served purposes 3, 4, and 5. The Department of Parks and Recreation, however, requested a three-lane road with two lanes uphill so that slow-moving recreation vehicles climbing the grade would not block traffic. This was granted, and the additional costs were allocated to the recreational cost of the State Water Project. The County of Los Angeles wanted a four-lane road and offered to pay the 11% difference in cost between a three-lane road and a four-lane road. This was accepted by the Department of Water Resources.

The 10-inch oil line owned by Cuyama Pipeline Company was relocated through the hills west of Castaic Valley.

Utilities in Elizabeth Canyon were rerouted along the relocated Lake Hughes Road. They consisted of

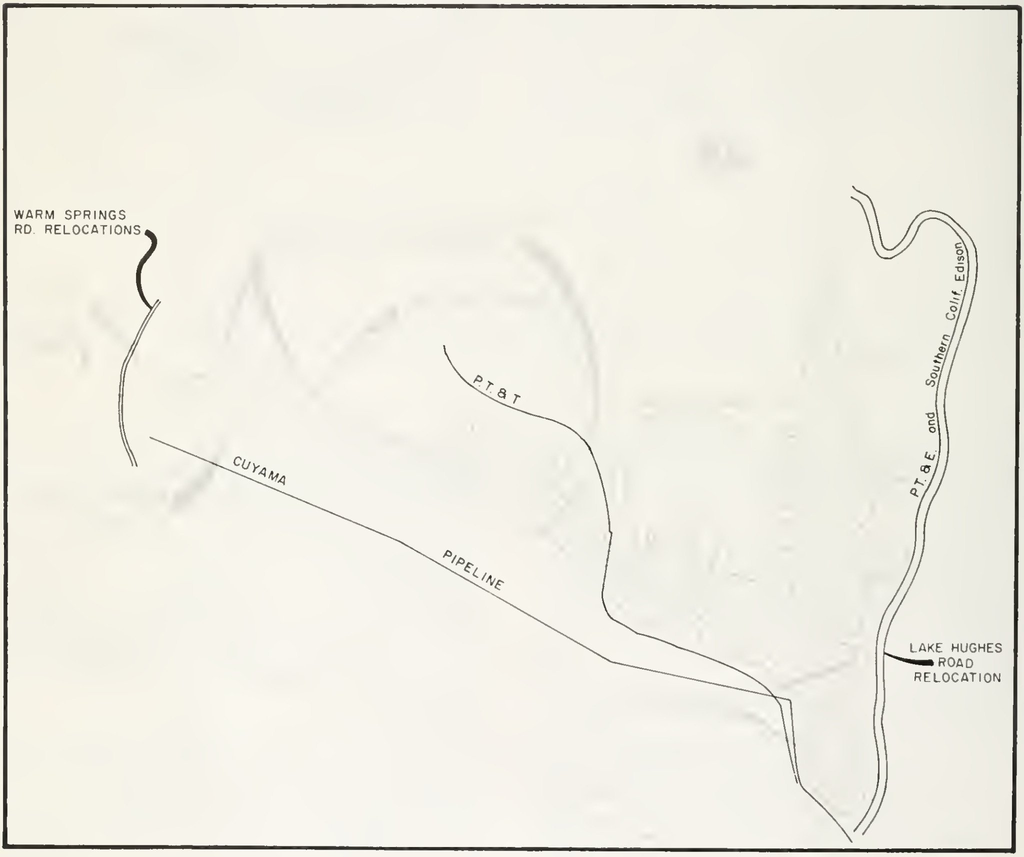


Figure 19. Castaic

telephone and power lines that were placed on joint-use poles. The telephone line across the north end of Castaic Valley was placed in a conduit which is now on the bottom of Castaic reservoir.

Relocations for Aqueducts

Public facilities, common carriers, and utilities all had to be relocated to accommodate the construction of the project aqueducts. The following discussion centers around the California Aqueduct because its width was typically responsible for the relocation problems which had to be solved. To cross the Aqueduct at close to a right angle, it was frequently necessary to relocate parallel to the Aqueduct on one or both sides to a point where a right-angle crossing could be made. In cases where there were several crossings in a short distance, such as a utility following section lines and the Aqueduct following contour lines, the utility was relocated parallel to the Aqueduct to eliminate the multiple crossings. In general, where the utility crossed at or near a right angle, relocation was done within the owner's original right of way.

Overhead

Before construction started on the Aqueduct, poles or towers were relocated so that overhead wires would span the finished Aqueduct. In cases where temporary relocations were required during construction, the permanent relocation was made after work on the Aqueduct was completed. In most cases where overhead telephone lines paralleled roads which crossed the Aqueduct, the relocated wires crossed the Aqueduct in a single span. Where the span was too great, such as on the Oroville-Chico and the Oroville-Cherokee Roads across Thermalito Power Canal, the telephone lines were placed in conduits under the curbs of bridges. Power lines, with their much higher strength-to-weight ratio and consequent longer span, could continue to go overhead in these instances.

Underground

The relocation of underground facilities such as gas, oil, and water pipelines was coordinated with the aqueduct contractor. Where possible, these facilities were supported by road bridges across the Aqueduct. If there were no bridges in the immediate vicinity, they were supported by a pier located at the centerline of the Aqueduct. In these cases, two alternative methods were employed. The first was to construct a temporary relocation through the construction area, then make a second move to the final location just prior to the completion of work on the Aqueduct. The second was to excavate the canal up to the facility, then make the permanent relocation across the open canal excavation.

Oil pipelines passing through the aqueduct embankment were encased in sleeves so that any oil leakage would drain to the outside of the embankment rather than into the Aqueduct itself. Additionally, if it becomes necessary to do maintenance on an oil line, the oil company can remove its line for repair or replacement without disturbing aqueduct embankment.

Rail and Highway

Because of grade requirements, railroads were crossed in two ways. First, where possible, the Aqueduct was aligned so that the water prism would be at an elevation with respect to the railroad grade which would permit bridges to be constructed across the Aqueduct above the water surface at the original grade level of the railroad. Second, where it was uneconomical to place the canal prism in sufficient cut, an inverted siphon was built under the roadbed leaving the railroad on its original grade and alignment. Each type of crossing required the railroad, through the construction area, to be detoured over a shoofly while the crossing was being built. Aqueduct service roads cross the railroad at grade at all points of intersection.

Road crossings generally were made at or above original grade with access to aqueduct service roads through gates at the grade of the crossing. The only case where the approach dropped below the existing road was for the road to the cement plant north of Quail Lake where the Aqueduct was in a deep cut. Here it was more economical to build a short, low-level bridge with long approaches rather than a long, high-level bridge with short approaches. The service road passed under the bridge.

Freeway crossings were built high enough above the Aqueduct so that maintenance roads could pass under the bridge. Exceptions were at the Mojave Desert crossing of Interstate 15, where the Aqueduct was siphoned under the freeway, and at several other locations where clearance under the bridge was inadequate for a maintenance road. In these instances, the Department's maintenance roads were connected to nearby local roads that crossed the freeway.

Subsidence Areas

The Department knew that subsidence was to be expected along the alignment in certain San Joaquin Valley areas where surface soils were unconsolidated, as discussed in Volume II of this bulletin. To bring about the necessary settlement, a series of temporary ponds was constructed on the right of way with the dikes between them serving as road crossings and as foundations for interim pipeline crossings. After the settlement process was complete, the permanent pipeline and road crossings were constructed.

Questionable Rights

Utilities Maintained on Revoeable Lieenses

In relocating various oil company facilities in the southern portion of the San Joaquin Valley, the Department found that many of the lines were located on private rights of way under licenses revocable by the landowner. In some cases, the right-of-way documents specifically required relocation at the expense of the owner of the pipeline. It was the Department's position that if it acquired the private property involved, it succeeded to the rights of the licensor, which rights included the right of relocation at the expense of the oil line owner, or in any event the right to revoke the license. To allow construction to proceed, the Department entered into agreements with the various companies for relocation whereby the Department would pay for relocation, retaining the right to recover costs plus interest should the courts rule in favor of the Department at a later date.

This matter was tested in a case against Texaco Incorporated and tried in the Superior Court of Kern County. The Court held that the license agreement was an easement and that the Department was obligated to pay the cost of relocation. The case was in turn appealed to the Court of Appeal. The decision of the Superior Court requiring relocation at the expense of the Department was affirmed. The California Supreme Court refused a hearing in the case. Based upon this decision, the Department will not pursue further litigation in this area.

Utilities Maintained Under Public Franchise

Many utility lines which the Department was required to locate to accommodate the Aqueduct were within the rights of way of streets and highways pursuant to franchises granted by local and state governments. The franchise documents invariably contained a provision requiring the utility owner to relocate its lines at its own expense when required for a proper governmental purpose.

As a test case the Department, through the State Attorney General's Office, filed an action in declaratory relief against the Southern California Gas Company. The Gas Company maintained gas lines under such a franchise in the City and County of San Bernardino. The franchise instrument contained relocation provisions which appeared favorable to the Department. The declaratory relief action sought a ruling that the Gas Company was obligated to relocate its franchise facilities at its own expense. The Gas Company demurred on the ground that the Department had not exhausted its administrative remedies, i.e., the dispute should have first been submitted and decided by the Public Utilities Commission. The demurrer was sustained and there have been no further proceedings in the controversy.

Exchange of Rights

The final step in the relocation procedure was an exchange of rights. With two facilities occupying the same right of way, agreements were necessary which gave recognition to the prior land rights of the parties, their future needs, maintenance problems that might affect both facilities, and future construction in the area of common use. The language in each agreement was tailored to recognize these conflicts in the new jointly occupied areas.

The most common types of documents executed were joint and common use agreements. The "joint use" agreement was used when the Department's construction required that all or a portion of the company's facilities be relocated so that its land requirements were changed. The "consent to common use" agreement was used when the company's facilities remained within the right of way that existed prior to the State's acquisition.

In cases where facilities of others were relocated in such a way that they did not cross the Department's facilities, it was preferable to have the owner quitclaim its original right of way in exchange for a new right of way outside the Department's property. Where this was not possible, an easement with essentially the same rights the owner had in its old right of way was granted within the Department's right of way. In all cases, existing rights were examined so that the Department could grant new rights to the owner similar to its rights in the original location. Where possible, identical rights were granted.

Present and Future Activities

Work on the Peripheral Canal is being conducted in accordance with the policies set forth above. It will involve nine major relocations, including railroads, pipelines, state highways, and the water supply pipelines for the communities on the east side of San Francisco Bay. More than 100 lesser relocations also will be made. The concentration of these, large and small, is not unusual for the 43-mile extent of the Canal. The cost is estimated at $24,000,000.

CHAPTER IV. PROJECT ARCHITECTURE

Architectural Motif

Early in 1963, the Department of Water Resources established a policy of creating a unifying architectural motif to be used with all structures of the State Water Project. In the ensuing months, the Department's architectural staff directed their efforts toward this goal, with consultation from the State Office of Architecture and Construction. In January 1964, the architectural motif of the State Water Project was approved. The architectural motif for the plants of the joint-use facilities in the San Luis Division was implemented by the U. S. Bureau of Reclamation prior to adoption of the Department's motif.

A brochure entitled "Architecture of the California State Water Project" was published in July 1964 describing the features of this motif which emphasized simplicity in the functional and structural use of concrete, steel, masonry, and glass. The color scheme of the motif included the use of accent colors of turquoise and red in contrast with the predominant grays, blacks, and whites of the many structures (Reference 1).

The Delta Pumping Plant and the adjacent operations and maintenance center for the Delta Field Division has buildings functionally typical of complexes throughout the State Water Project. This facility, one of the first to be constructed, was used as a prototype for development of the architectural motif. The plot plan on Figure 20 shows the design concept for this complex, and Figure 21 shows the facility as it was constructed. As the dominant structure of the complex, the Pumping Plant was the focal point in designing the motif.

The architectural motif strives for simplicity and economy in structural form and ease of erection; thus, steel framing was used for the superstructure. A precast concrete wall panel system on the superstructure was used to reflect the mass concrete in the substructure. At plants near earthquake-prone areas, metal insulated panels were used instead of precast concrete to reduce lateral loads. To relate the massive structure of the Delta Pumping Plant and other plants to a human scale, windows and textured concrete block were introduced under the precast concrete wall panels at the main floor level.

The Delta Pumping Plant, like most large pumping plants, is quite long in relation to width and height because of the straight-line arrangement of the 11 pump units serviced by one overhead bridge crane. However, by exposing the outer flanges of the steel frames to the exterior, vertical elements were introduced to improve proportions and provide architectural expression that this is indeed a steel-framed structure (Figures 22 and 23).

Minimum use of cross bracing was emphasized in framing of the structures. By using metal roof decking to transfer horizontal forces, cross bracing in the roof plane was eliminated entirely.

Many plant roofs are exposed to public view, particularly those set in deep excavations. It was, therefore, desirable to treat these roofs in a manner pleasing to the eye. However, any architectural treatment should be functional and not solely decorative. To prevent the roof from appearing as a monotonous plane, plastic-domed skylights or skylights in combination with ventilators were introduced in a pattern set by the framing. These skylights transmit natural light to the interior during the day and emit artificial light to the exterior during the night. The roofs are free from extraneous mechanical equipment.

At the Delta Pumping Plant, the visitors building is set away from the main structure. Visitors may ascend a flight of stairs in the building, cross a glass-enclosed bridge into the plant, and view the motor floor from an observation gallery (Figure 24). Aluminum baluster railings were installed around visitor areas. At other plants, the use of an attached visitors building was eliminated in favor of visitor facilities within the plants themselves.

For low maintenance, many exterior concrete surfaces are unpainted. Precast concrete panels of major structures are texture-coated. Color schemes are compositions of grays, blacks, and whites with strategic use of bold accent colors of turquoise blue and flaming red, symbolizing water and power. This is the basic color scheme applied to all State Water Project structures.

Application of the architectural motif to smaller buildings, using precast panels, is illustrated on a typical warehouse and carpenter shop (Figure 25). Precast concrete panels, in this case, were broom-finished with no further surface treatment. Figures 26 and 27 show the motif applied to a vehicle maintenance building. Another interesting example of application of the motif is the Administration Building at the Delta Field Division complex (Figures 28 and 29). Del Valle Pumping Plant illustrates the motif adapted to a small pumping plant (Figures 30 and 31).

The architectural motif was followed on other structures as well. Figures 32 and 33 show application of the motif to the tunnel portal at Edward Hyatt Powerplant. Other structures, such as check structures, bridges, and overchutes, carry on the architectural motif in simplicity of form, color, and railing style where practical (Figure 34).

One of the most dramatic applications of the motif was made to switchyard structures. Simplicity of form was achieved by use of welded structural shapes rather than standard latticebar structures. The motif color scheme applied to these structures was designed to symbolize hydroelectric power (Figures 35 and 36).

Environmental Considerations

Preservation of natural landscape has been one of the Department's goals in State Water Project construction. The natural landscape was left as undisturbed as engineering requirements permitted. Excess material from excavations was placed to blend with the adjacent environment. Where this material was distributed along the California Aqueduct, contours on the aqueduct side were extensions of aqueduct slopes. In other visible areas, contours are gently rounded, avoiding sharp breaks and straight lines, and revegetated with native plants to blend with the natural landscape.

A general concept for landscaping State Water Project facilities included the following features:

1. Working Conditions—Overall appearance of the buildings and grounds is an important factor in personnel morale and efficiency.

2. Environmental Control—Control of dust is especially important in the windy, dry areas typical of the locations of many of the State Water Project facilities. Low-maintenance plantings in keeping with the local flora are used in the facility area. Tree plantings are used to provide wind screens and shade for buildings and equipment. Ground covers around buildings are used to control dust and reduce the heat load on building cooling equipment.

3. Traffic Control—"Living fences" supplement chain-link fences to channel traffic and keep visitors away from restricted areas. Planters around buildings protect the walls from damage by vehicles and also protect pedestrians from protrusions and rough-textured walls. Planter strips outline vehicular traffic flow to prohibit dangerous shortcuts.

4. Screening—Plantings around unsightly outdoor storage and working areas screen them from view and eliminate the need for expensive walls.

5. Irrigation Systems—Automation of irrigation systems is provided dependent upon individual studies of manpower and economics.

Building Codes

Architectural criteria include applicable building codes governing design of buildings and structures. All state-owned or occupied buildings must conform to regulations of the California Administrative Code, Title 8 and Title 24, and the Uniform Building Code (References 2, 3, and 4). Enforcement agencies are the Department of Industrial Relations (Division of Industrial Safety) and the Office of State Fire Marshal.

Title 8 pertains to providing safe working conditions and specifies requirements for the design of access to working areas, such as stairs and ladders, and construction of the working area itself.

Title 24 defines and classifies occupancy functions and types of construction and specifies requirements based on occupancy and construction.

The Uniform Building Code specifies design criteria for exits, stairways, corridors, and access for the handicapped; it establishes fire-resistive standards for fire protection based upon flame spread, fuel contribution, smoke development, and heat transmission of building materials.

Architectural Awards

In May 1971, the American Public Power Association gave recognition to the architectural design of two facilities of the State Water Project. Their "First Honor Award" went to the Delta Pumping Plant. The jury commented that " . . . . it shows an unusual perception and awareness of the potential of this site. If you are going to reshape Mother Earth, it's nice to do it in an ordered way. The design of the individual buildings is well above the standard. They are distinguished and businesslike and look like buildings designed to fulfill the functions they serve." The jury also conferred their "Honor Award" upon the Oroville-Thermalito Hydroelectric Complex. They commented that ". . . it represents a strong structural form as a man-made contribution to the area. This can clearly be recognized as a contribution of utility architecture to the natural landscape. It is a clear and powerful expression of the functions it serves, and the use of color throughout the project is highly commendable."

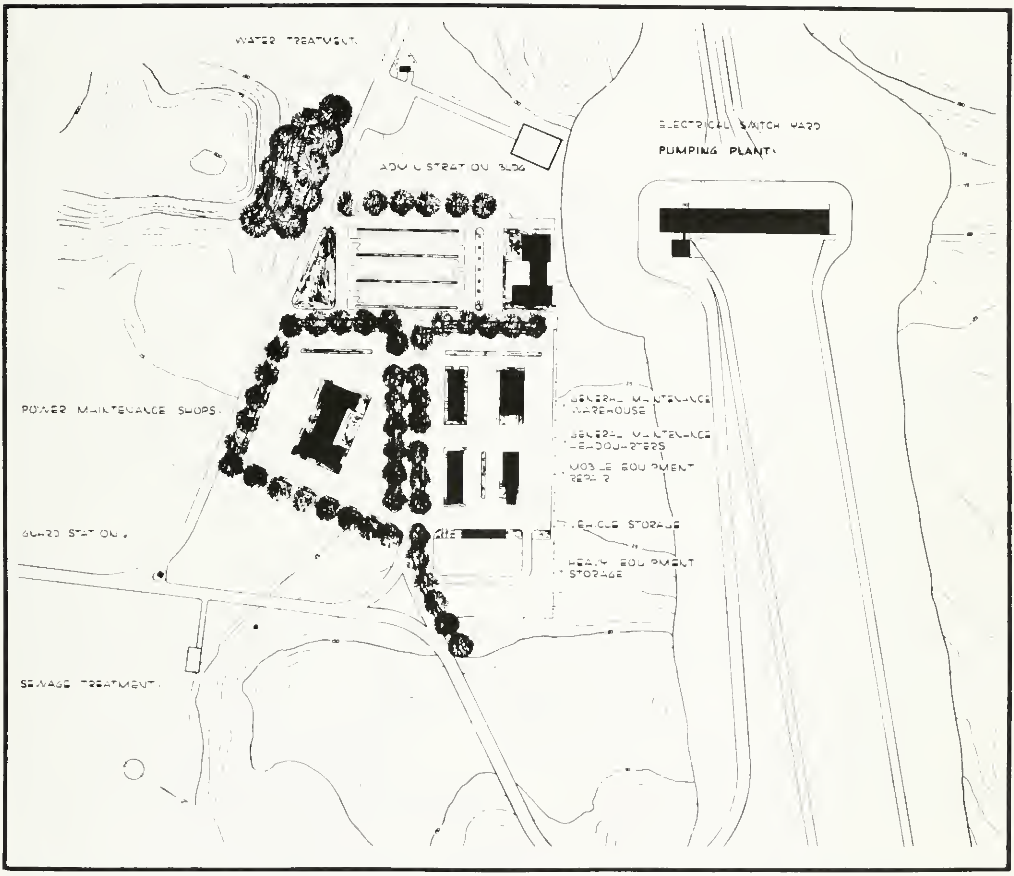


Figure 20. Delta Field Division and Delta Pumping Plant Complex—Plot Plan

Figure 21. Delta Field Division and Delta Pumping Plant Complex—Completed Facilities

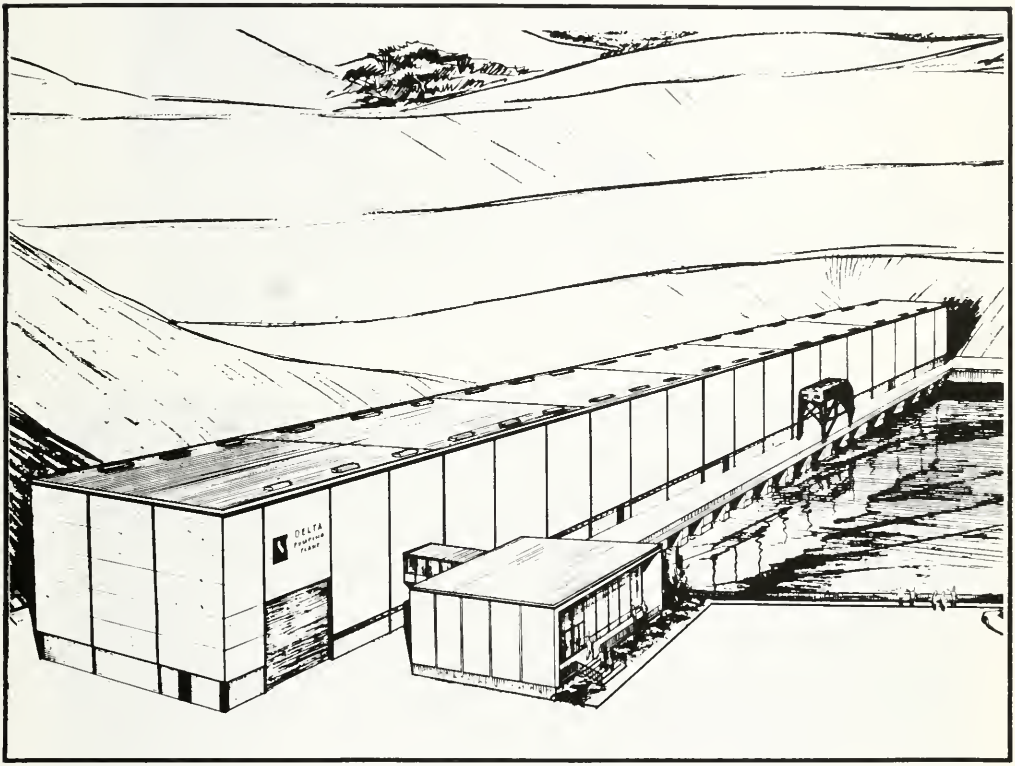


Figure 22. Architectural Rendering of Delta Pumping Plant

Figure 23. Delta Pumping Plant

Figure 24. Delta Pumping Plant Interior

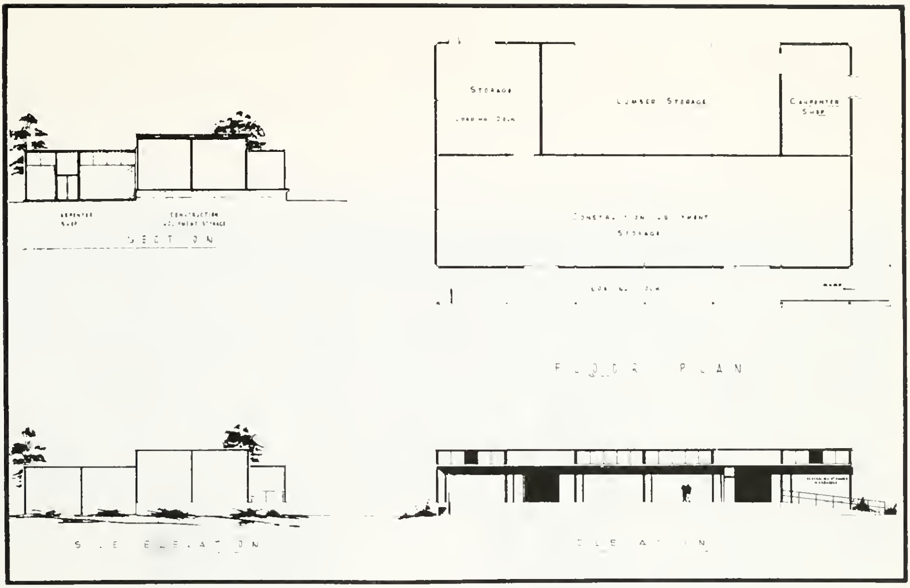


Figure 25. Warehouse and Carpenter Shop

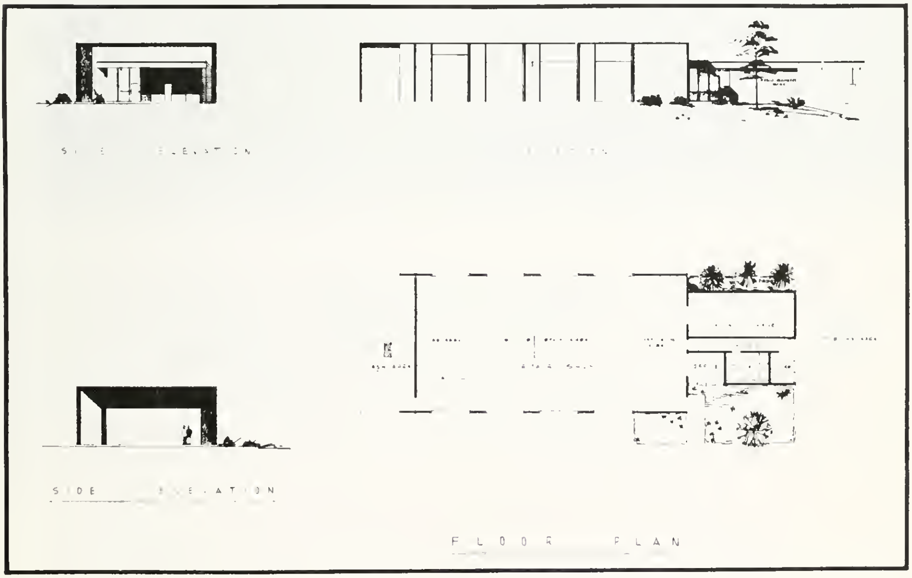


Figure 26. Vehicle Maintenance Building—Architectural Rendering

Figure 27. Vehicle Maintenance Building—Completed Structure

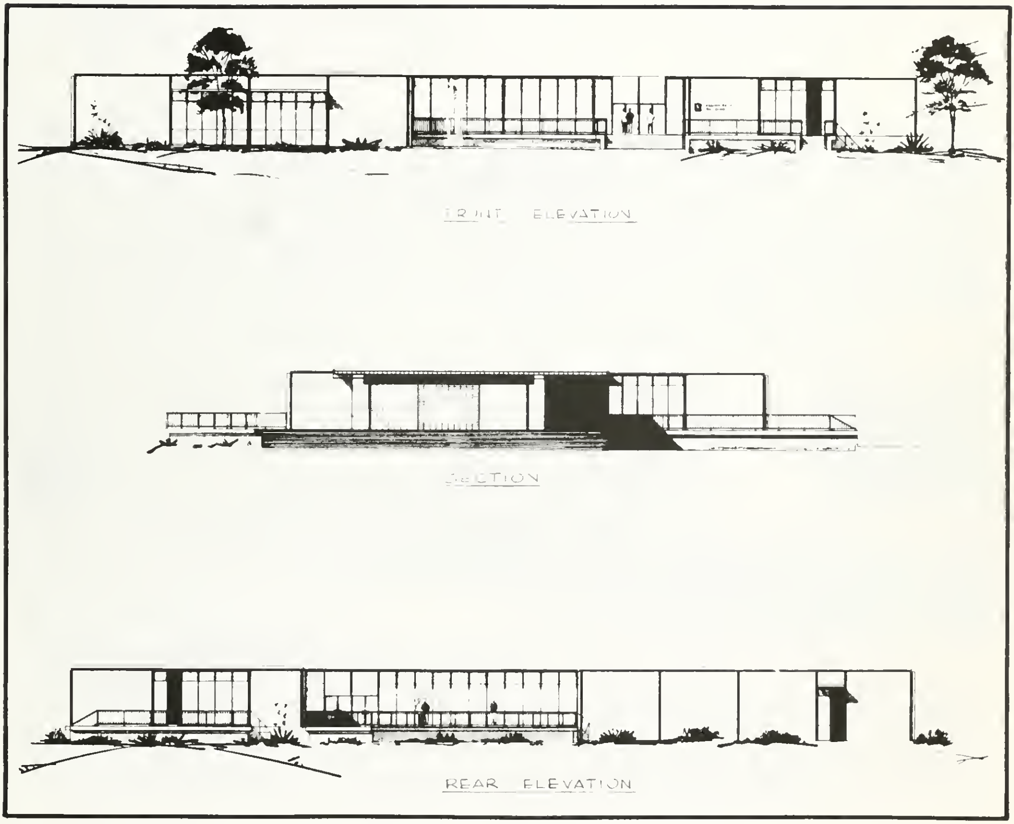


Figure 28. Delta Administration Building—Architectural Rendering

Figure 29. Delta Administration Building—Completed Structure

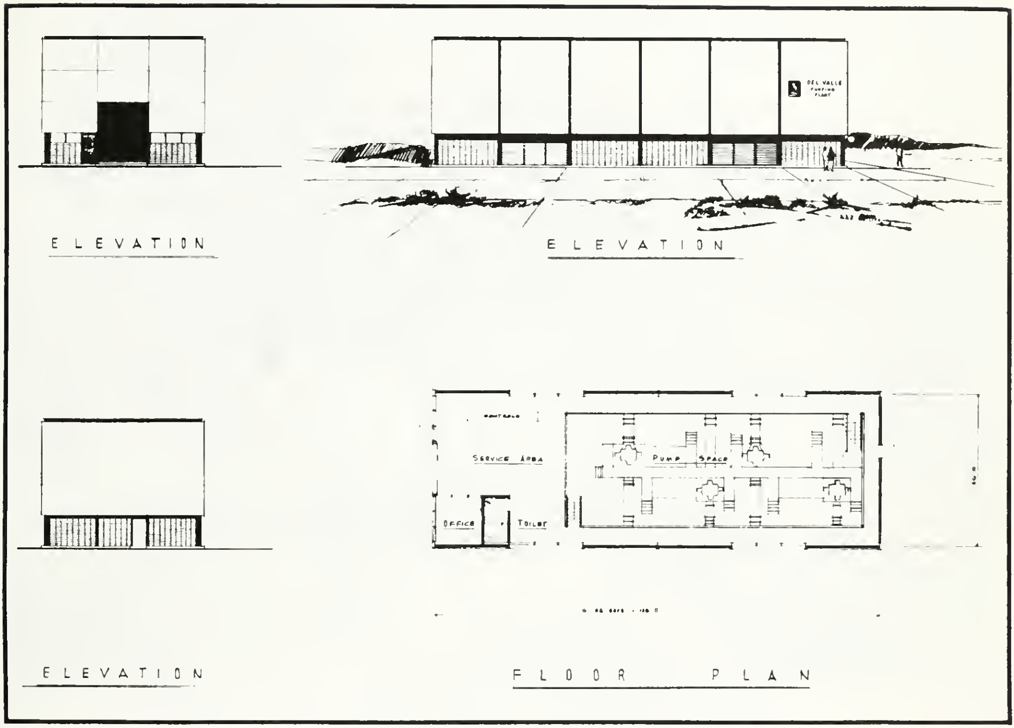


Figure 30. Del Valle Pumping Plant—Architectural Rendering

Figure 31. Del Valle Pumping Plant—Completed Structure

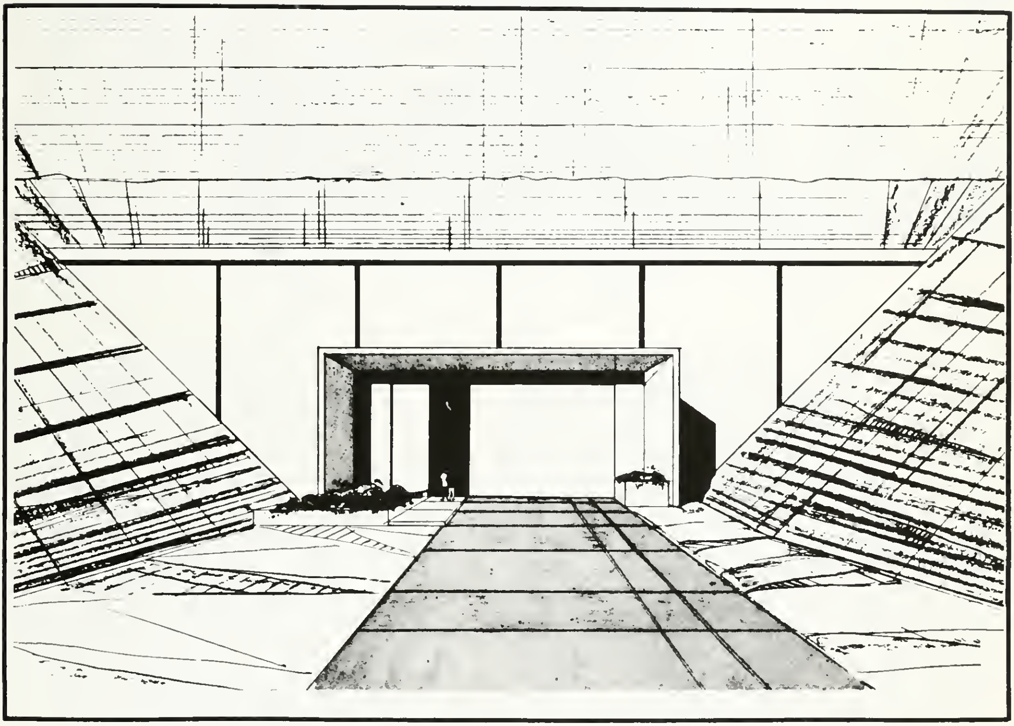


Figure 32. Edward Hyatt Powerplant Entrance—Architectural Rendering

Figure 33. Edward Hyatt Powerplant Entrance—Completed Structure

Figure 34. Check Structure and Adjacent Control Building

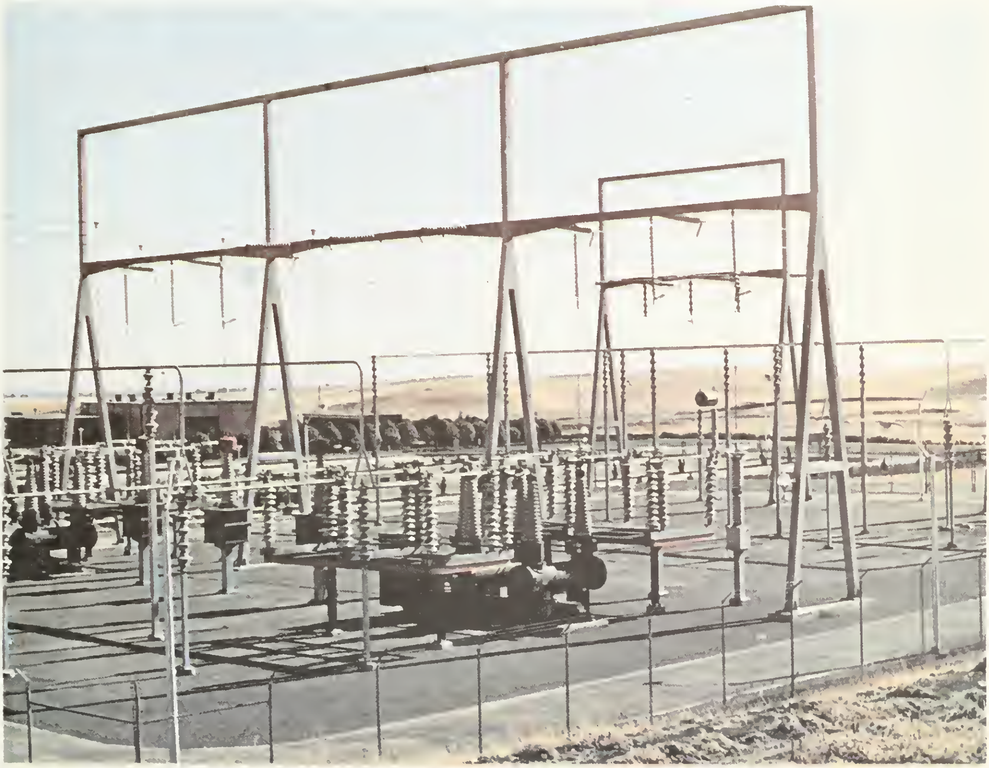


Figure 35. Delta Pumping Plant Switchyard

Figure 36. Edward Hyatt Powerplant Switchyard Towers

References

(1) California Department of Water Resources, "Architecture of the California State Water Project", July 1964.

(2) California Administrative Code, Title 8, Industrial Relations, Office of Procurement, Documents and Publications.

(3) California Administrative Code, Title 24, Building Standards, Office of Procurement, Documents and Publications.

(4) Uniform Building Code, International Conference of Building Officials, Whittier, California.

CHAPTER V. GEOLOGIC AND SEISMIC INVESTIGATION

Planning, designing, and building of the California State Water Project were influenced by a variety of geology-related factors, particularly the State's seismicity. Most of its structures were and will be affected to some degree by their geologic environment. Because the Project is largely a civil engineering undertaking, geologic and seismic investigations were programmed to produce the information required for planning and design purposes. A basic aim was to interpret and present pertinent observations in a form that would be understandable and useful to engineers of various disciplines.

Investigations of sites for specific structures are contained in other volumes of this bulletin, notably Volumes II, III, and IV. However, in addition to these specific local studies, there were programs of broader scope which influenced major decisions and policies concerning selection of the aqueduct route and the location, design, and operation of major facilities. Summaries of these special programs are included in this chapter.

Engineering Geology

The Role of the Geologist

There was unprecedented use of engineering geologists during all stages of the Project. During the peak period of planning and construction, 134 earth scientists were employed. These included 128 engineering geologists, 2 exploration geophysicists, 2 seismologists, and 2 geochemists. Fifty-four engineering geologists were assigned as a unit to the Department's design and construction activities and worked full time on the State Water Project.

Heavy demand for geologic services was due to the enormity of the Project and complexity of the geology within the region through which the Project passed. For most of the dams, tunnels, power plants, pumping plants, and bridges, alternative sites were considered. Furthermore, more than 100 variations in the aqueduct alignment were examined before selecting the final route.

A major task was the identification of geologic hazards. These are defined as those conditions which would pose serious threat to life, public property, or the Project. Geologic hazards include: earthquakes, faults,land subsidence, landslides, and seepage.

Other tasks included:

1. Providing descriptions of geology-related conditions that could influence the design, construction, or operation of the Project.
2. Locating and evaluating sources of construction materials.
3. Compiling records of geologic explorations including geologic maps, logs, surveys and reports, and maintaining a depository for this information.
4. Compiling geologic records during construction, including geologic maps, logs, and seismitron readings; special reports on construction problems; and summary reports upon completion of construction.

Investigations were undertaken usually as team efforts in which geologists and engineers jointly participated. Under this concept, the product of each study was the result of a unified effort. This procedure was found more effective than the practice wherein each discipline undertakes an independent investigation leading to a separate report.

In the investigation of surface and subsurface conditions, logging and sampling of drill holes was undertaken by engineering geologists. The extent to which logs and samples represented the mass from which they were extracted and the interpretation of geological conditions were the domain of the geologist.

Subsurface Exploration

During the peak years 1964 through 1968, annual expenditures for drilling and geophysics averaged about $1.7 million which included costs of exploring canals, tunnels, and damsites. About one-half of the drilling was undertaken with department crews who operated 12 state-owned and up to 14 rented drill rigs (Figures 37 and 38), while the remainder was done by contractors. Each drilling operation was supervised by an engineering geologist who examined and classified drill cuttings, boxed rock core samples, and prepared a geologic log (Figure 39). Geophysical investigations included seismic, electrical resistivity, gravity, and magnetic surveys (Figures 40 and 41).

The San Andreas Fault

Most great earthquakes in California are generated along the San Andreas fault (Figures 42 and 43). This great fault trends southeasterly from the coastline north of San Francisco to the Gulf of California, a distance of about 650 miles. The San Andreas is known technically as a ridge-ridge transform fault, which marks the contact between the North American and Pacific tectonic plates. Correlation of formations on either side of the fault indicates an aggregate lateral displacement of possibly as much as 350 miles since Jurassic time. Occasional contemporary earthquakes attest to its continuing activity.

Throughout most of its length, the California Aqueduct parallels (within 30 miles) the San Andreas fault zone. It crosses the fault at four places. For these reasons, the San Andreas fault was studied in detail to understand better the nature and frequency of its displacements and the regional deformations of ground surface that have occurred in its vicinity during the past.

Two historic earthquakes generated on the San Andreas fault are noteworthy because of their impact on the aqueduct studies. One of these earthquakes occurred in 1857 and the other in 1906.

Figure 37. Failing 2500 Drill Rig

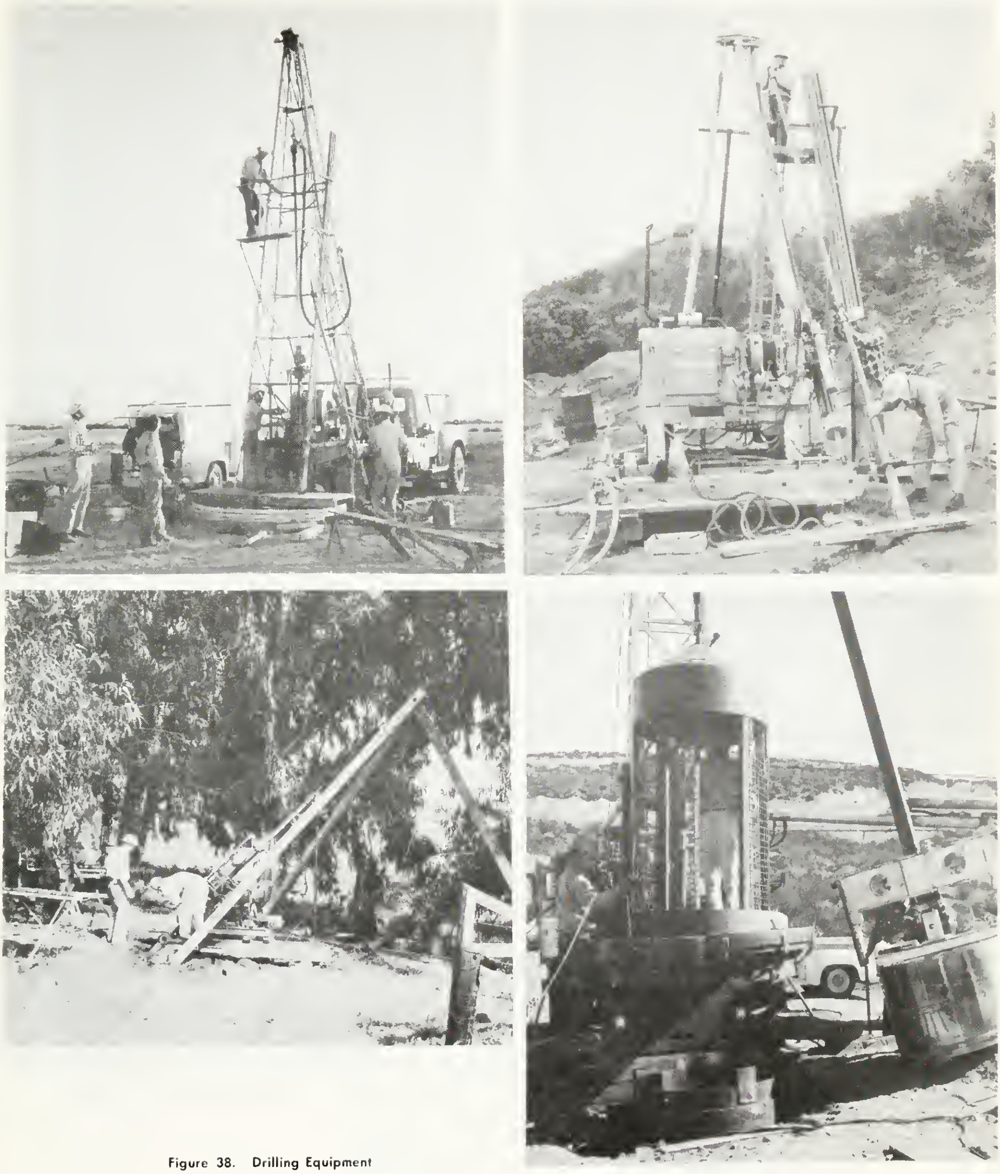


Figure 38. Drilling Equipment

Figure 39. Typical Drill Hole Logging Operations

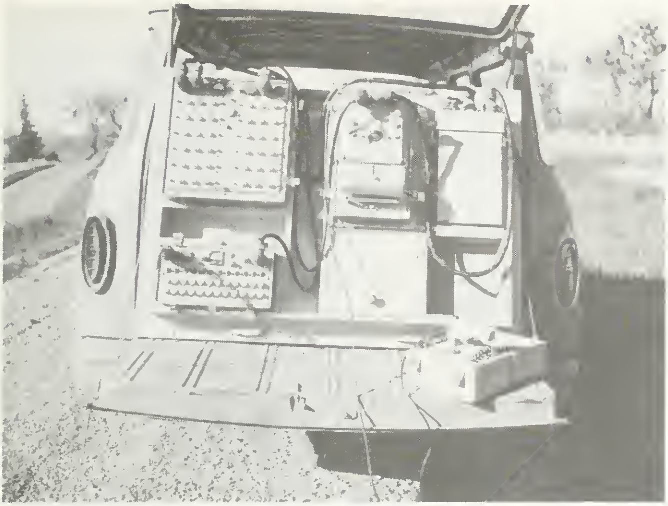


Figure 40. A Refraction Seismograph with Amplifier, Oscillograph, Input Unit, and Blaster

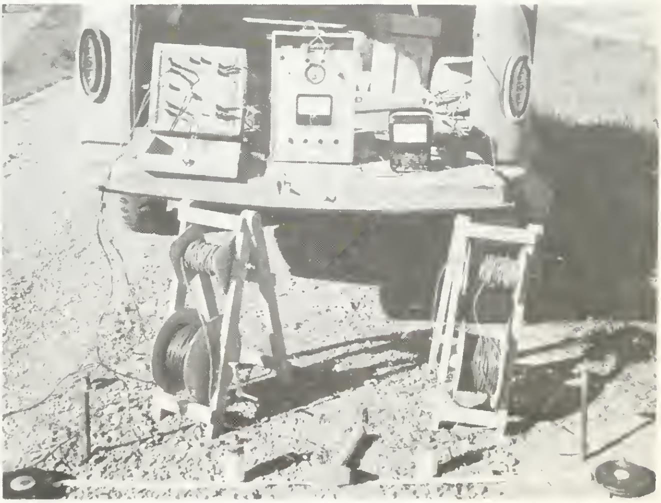


Figure 41. A Proton-Precession Magnetometer

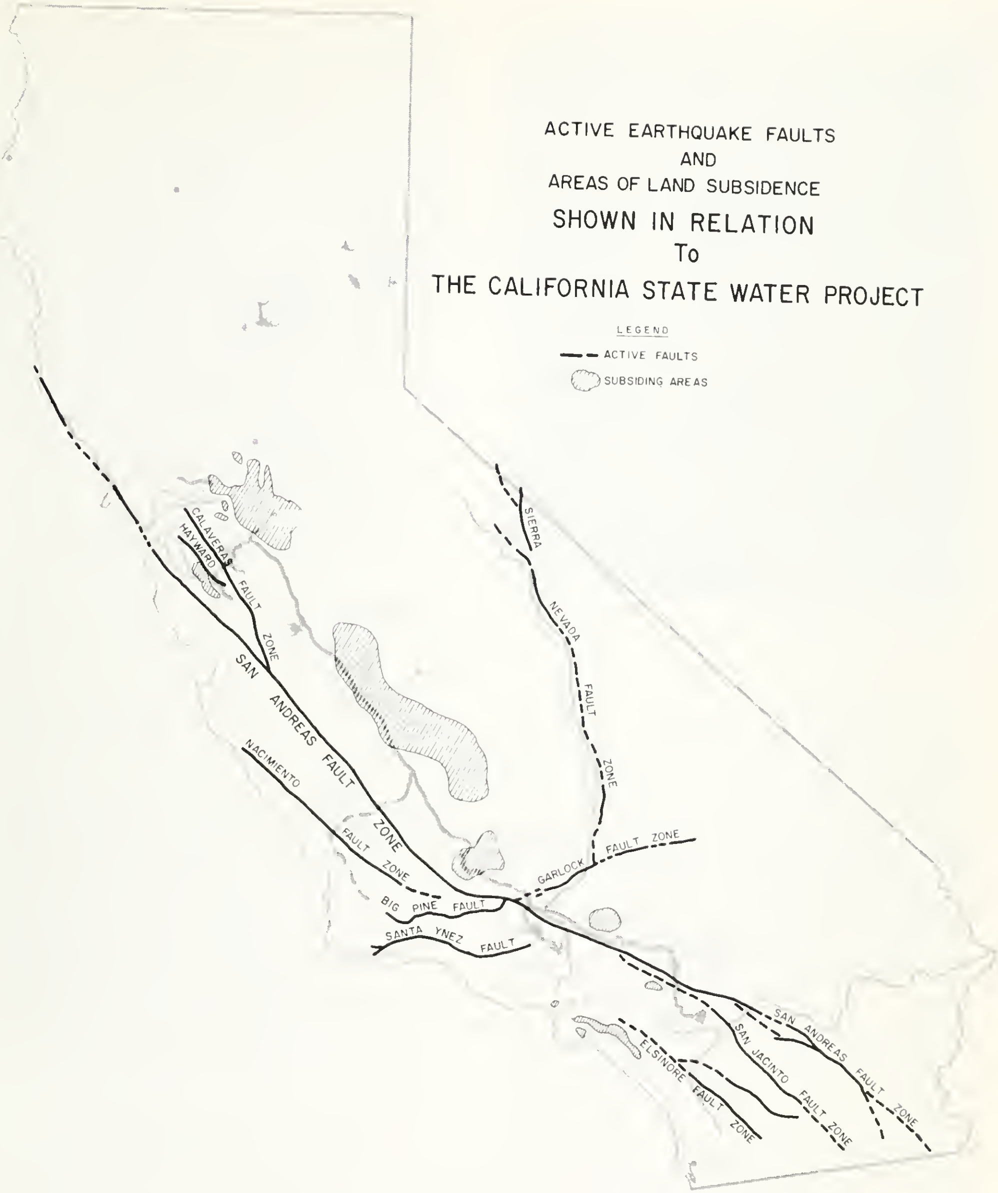


Figure 42. Active Earthquake Faults and Areas of Land Subsidence

Figure 43. San Andreas Fault Where it Crosses the Carrizo Plain West of Taft

The 1857 earthquake occurred in Southern California. Most of the region affected was only sparsely inhabited at that time. Nevertheless, the shock caused considerable disturbance and was felt throughout the southwestern United States. The ground surface along the trace of the fault may have ruptured over a length of 200 miles. Inspections of offset stream channels indicate that displacement was in a lateral sense and on the order of 30 feet. Although the seismograph had not yet been invented, it is generally believed that this shock must have exceeded 8.0 on the Richter scale. A number of geologists contend that it is the strongest experienced in California since civilization of the State.

The 1906 earthquake is commonly known as the great San Francisco earthquake because of the death, destruction, and fires it caused in that city. The comparatively crude seismographs of that day indicated that the maximum shock was about 8.3 Richter magnitude. During this event, the surface trace of the San Andreas fault was ruptured for about 200 miles. Maximum lateral displacement was about 20 feet. Some geologists believe that this earthquake exceeded the 1857 shock in severity.

Four dams and reservoirs owned by the City of San Francisco, located both in and near the active zone of San Andreas fault, remained intact during this earthquake. The experiences of the San Francisco water supply system during the 1906 temblor demonstrated that California's great earthquakes did not present insurmountable problems and that, by prudent geologic and engineering planning, damage could be minimized and a reasonably safe and reliable California State Water Project could be constructed.

Geologic Studies of the Tehachapi Mountain Crossing

In routing the California Aqueduct through the Tehachapi Mountains, consideration was given to the characteristics of existing aqueducts. Possible effects of future major earthquakes on water deliveries to Southern California as a result of damage to the water supply system for the area was a prime consideration.

There are two aqueducts in addition to the California Aqueduct which convey water into the Los Angeles coastal plain. These are the Los Angeles Department of Water and Power Owens Valley Aqueduct fed from the east slopes of the Sierra Nevada, and The Metropolitan Water District of Southern California Colorado River Aqueduct which diverts water from the Colorado River. Recurrence of an earthquake on the order of the 1857 temblor could disrupt these systems where they cross the San Andreas fault.

An additional source of water in Southern California is provided by wells drilled in the coastal plain. Ground water comprises approximately 40% of the total, annual, dependable, water supply to this area. Experience has shown that ground water supplies may be interrupted during earthquakes by shearing and collapsing of well casings; damage to deep-well turbine pumps; and destruction of electrical facilities, such as transmission lines, switchyard apparatus, and pole transformers.

Realization that nearly all water supply for Southern California could be jeopardized by a major earthquake prompted careful studies of the routing and design of the California Aqueduct through the seismically active Tehachapi range, particularly at the crossings of the San Andreas fault. The goal of these studies was to construct facilities which could be returned to service quickly following a damaging earthquake. Exceptional concern was expressed for aqueduct reliability in view of the possibility that other sources of supply could be interrupted for a considerable period of time. Two basically different plans were proposed; both involved crossing the San Andreas fault, but each differed in the manner in which that crossing would be accomplished.

One of the proposed alignments was known as the Long Tunnel Route or 1870 Tunnel (1870 being the elevation of the crossing in feet above sea level). This route included a tunnel approximately 20 feet in diameter and 27 miles in length which extended from the southernmost tip of the Central Valley to Castaic reservoir. No pumping lift would be required. This alignment passed beneath the Tehachapi Mountains with a maximum cover of 3,900 feet, and it penetrated the San Andreas fault at a depth of 1,800 feet. It also intersected at depth five other major faults with questionable habits: the North Garlock, Garlock, German, Liebre, and Clearwater faults. Formations exposed along the alignment included crystalline igneous and metamorphic rock, sandstones, shales, conglomerates, and limestone. This alignment was abandoned because of difficult tunneling and the possibility of prolonged shutdown from an earthquake-activated fault displacement in the tunnel.

An alternative to the Long Tunnel Route has been constructed and is now in operation. It is known as the High Line or 3360 Route, the numbers again reflecting tunnel elevation in feet above sea level (Figures 44, 45, and 46). This route includes a pumping plant of unprecedented size which can lift 4,410 cubic feet per second of water a height of 1,926 feet in a single lift. Pumps deliver water to a series of four tunnels driven through the crest of the Tehachapi range, the longest of which is over 25,000 feet in length. Selection of the alignment for these tunnels was based on an extensive program of geologic investigation. All crossings of active earthquake faults by the tunnels were accomplished at ground surface, where repairs to possible earthquake damage can be made quickly (Figures 45 and 46).

For this tunnel alignment, most of the Aqueduct near the San Andreas fault remains on the surface downstream from the Tehachapi crossing. Where the Aqueduct crosses the San Andreas fault, check structures are provided to isolate the crossing in the event of earthquake damage (Figure 47). This policy was observed throughout the length of the California Aqueduct as discussed in Volume II of this bulletin.

As an overriding protection against acute water shortage resulting from an earthquake-related outage, additional storage was provided in the terminal reservoirs of the State Water Project—Castaic Lake and Lake Perris. These reservoirs are located south of the Tehachapi range and downstream from the San Andreas fault.

Geologic Investigation of Potential Land Subsidence

The California Aqueduct consists largely of a canal constructed on gradients averaging about 1 foot of drop for each 4 miles of reach. Because of this comparatively gentle slope, small changes in ground elevation can significantly affect the Aqueduct's performance. A program of land subsidence investigation was undertaken in the San Joaquin Valley to detect and delimit susceptible areas (Figure 42), estimate ultimate settlements, determine causes and mechanics, and develop effective countermeasures. Geologic investigation was related chiefly to the initial stage of this program, namely the delimitation of areas vulnerable to land subsidence. It involved geophysical surveys, geologic mapping, field testing, and experiments.

Four types of land subsidence were recognized in the regions proposed to be crossed by the Aqueduct. These included subsidence caused by:

1. Ground water extraction (deep subsidence)
2. Hydrocompaction (shallow subsidence)
3. Oil and gas production
4. Tectonic activity

Ground Water Extraction (Deep Subsidence). Heavy extraction of ground water for crop irrigation has caused subsidence ranging up to 23 feet over several hundred square miles of the San Joaquin Valley. These depressed regions are not discernible to the eye because of their great areal extent. Such subsidence generally is manifested first by a reduction in the carrying capacities of canals and drainage ditches.

Subsidence due to fluid extraction is a soil consolidation process. Increase in effective intergranular pressure which activates the process is related to lowering artesian and water table elevations. It consists of downward seepage forces due to the passage of water through the aquicludes overlying the artesian zones supplemented by forces resulting from decreased buoyancy within the shallow aquifers that are dewatered. Compression of the deep sedimentary deposits, particularly the beds containing abundant clay and silt, has resulted. Reduction in the thickness of these deposits is reflected on the surface as a depressed bowl. Investigations of this phenomenon were undertaken cooperatively over the last 18 years by the U.S. Geological Survey and the California Department of Water Resources. Development of the compaction recorder by the U.S. Geological Survey assisted greatly in developing an understanding of the mechanics of the process and its relationship to hydrogeology (Figure 48). This device is essentially a water-stage recorder which is linked by a wire to an anchor placed at the bottom of a drill hole or abandoned well. Subsidence due to compaction or consolidation of soil layers results in a shortening of the suspended cable. This causes the recorder sheave and drum to rotate, resulting in inscription of a graphic record of compaction. By installing these devices in wells of different depths, it was possible to record the compaction occurring within selected depth intervals.

Identification of subsidable areas was accomplished largely by hydrogeology studies in which areas underlain by artesian aquifers were delimited and pertinent physical characteristics of underlying sediments were determined.

Crops in the San Joaquin Valley are dependent upon well irrigation and are valued in millions of dollars; consequently, any restriction of pumpage was considered to be economically and politically unfeasible. However, it was reasoned that, once in operation, the California Aqueduct would provide irrigation water generally at a cost less than the cost of well water and that a curtailment in ground water use would automatically result. The validity of this logic subse-

Figure 44. The Tehochopi Mountains with A. D. Edmonston Pumping Plant in the Foreground

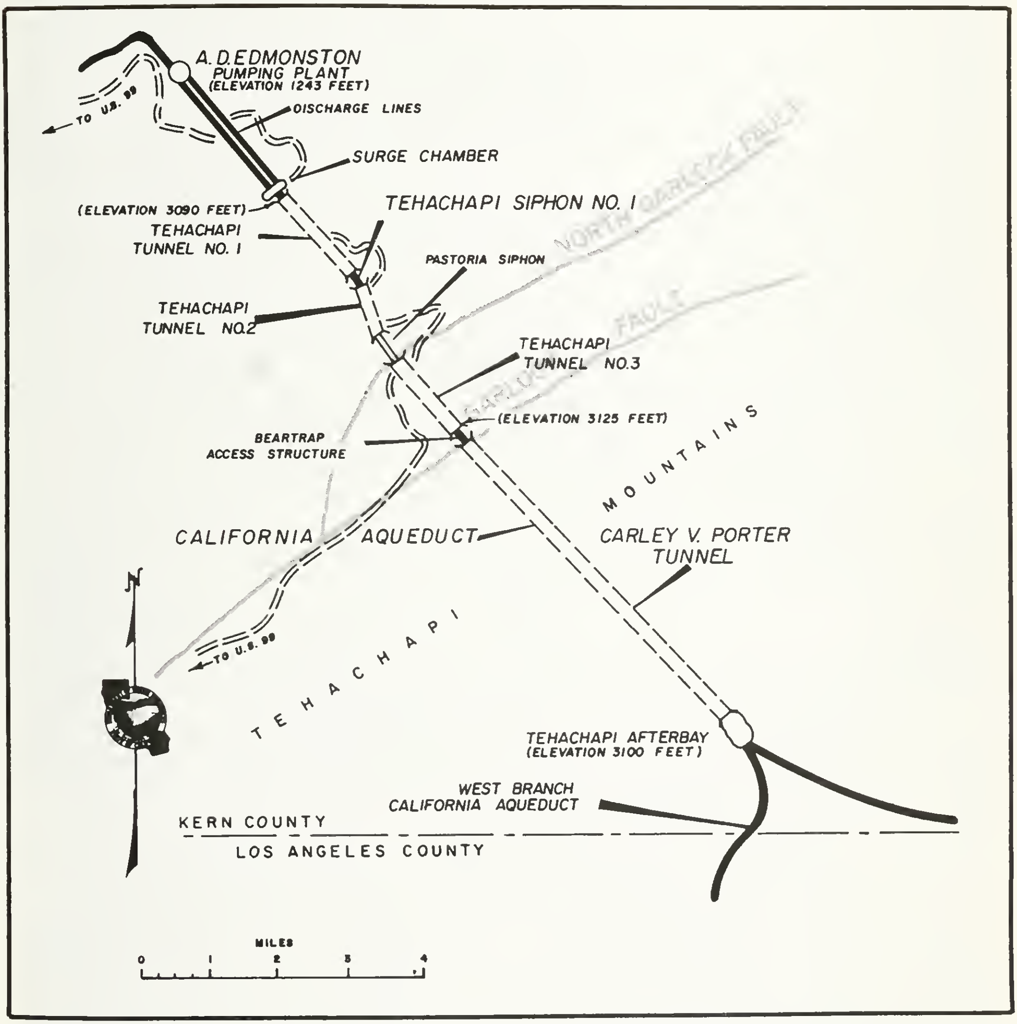


Figure 45. Aqueduct Route Through the Crest of the Tehachapi Mountains

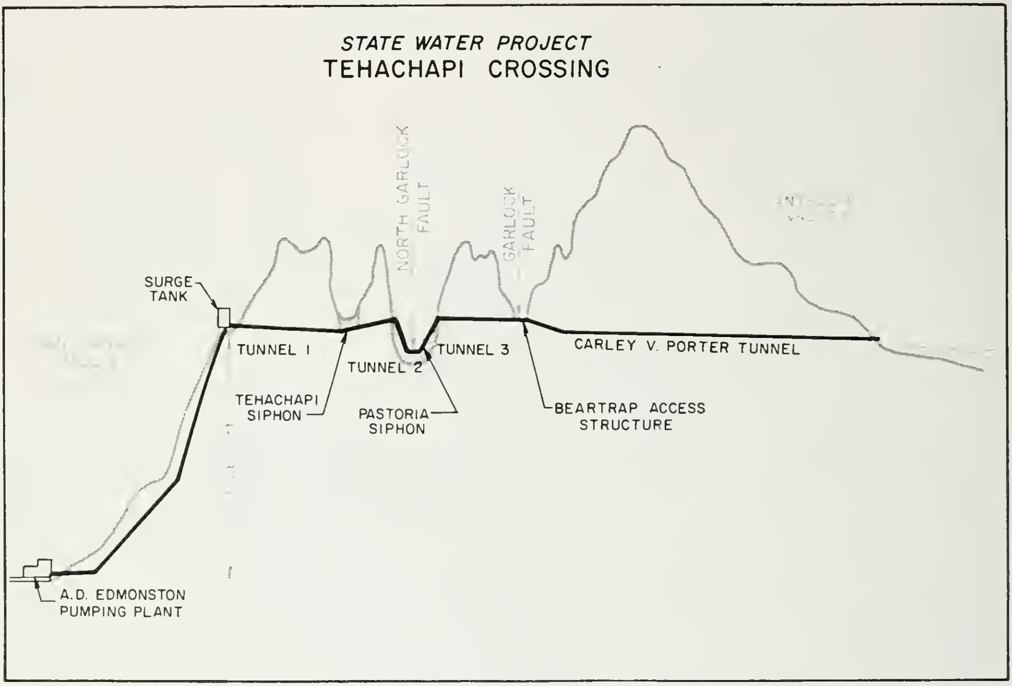


Figure 46. Profile of the Tehachapi Mountain Aqueduct Crossing

Figure 47. Aqueduct Crossing of the San Andreas Fault

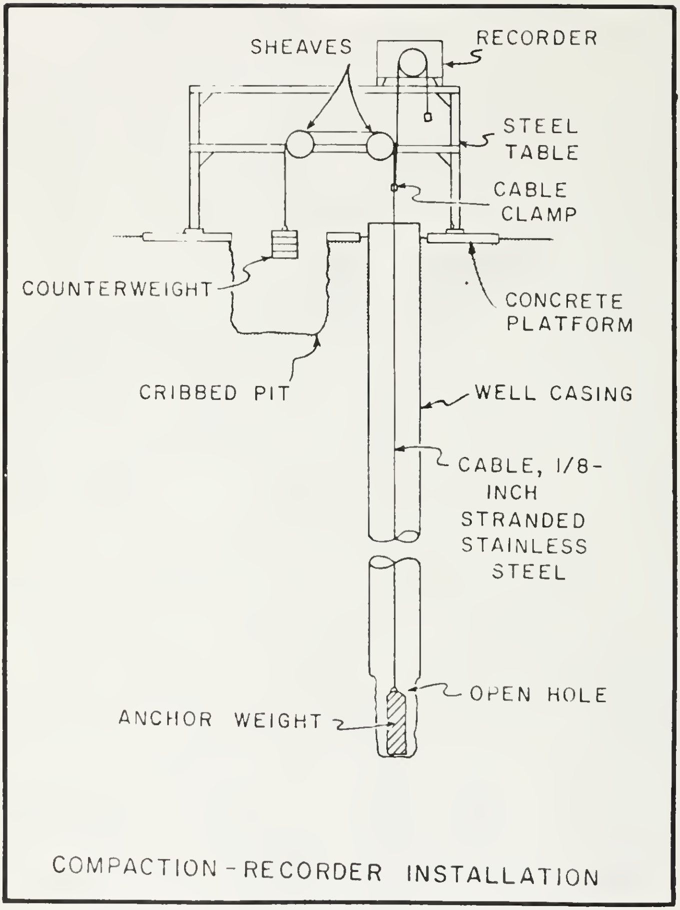


Figure 48. A Compaction Recorder Installation

quently has been demonstrated and the rate of deep subsidence has diminished progressively in recent years in portions of the San Joaquin Valley.

Certain features were included in the design of the canal to compensate for subsidence that might occur during the period in which the switch from ground water to aqueduct water took place. These provisions included constructing additional freeboard in canal embankments and designing them so that they can be raised if necessary. Crossover structures, such as certain roads, bridges, and pipelines, were designed so that they can be lifted by jacks should raising of the embankments be required. In some areas along the Aqueduct in the San Luis Division, the canal lining and some bridges have been raised to compensate for deep subsidence because of a delay in the construction of distribution systems.

Hydrocompaction (Shallow Subsidence). Hydrocompaction has been defined as vertical, downward, surface displacement resulting from compaction of underlying, low-density soils by application of a sufficient quantity of water. It is the result of compaction and differs from normal consolidation in that a rearrangement of soil particles occurs when water is applied to the susceptible sediments.

As a general sequence of events, lined canals, ditches, and concrete pipelines passing through regions vulnerable to hydrocompaction generally will develop some leakage resulting in settlement. This, in turn, leads to increased subsidence. Thus, cracking and leakage progressively increase until the system requires extensive repairs or abandonment.

Areas susceptible to hydrocompaction were identified in the San Joaquin Valley on the steep fans of secondary streams where mudflow deposits are common. Such deposits have accumulated to depths exceeding 200 feet in some places. It was found that the fans of the principal streams generally do not subside, probably because they have been saturated repeatedly in the past by natural streamflow. Hydrocompaction occurs in regions of low annual precipitation. Susceptible areas in the San Joaquin Valley experience an average annual rainfall ranging between 5 and 7 inches. This often occurs in torrential downpours resulting in quasi-saturated mudflows.

Laboratory tests and in-place measurements of the shear strength made in the field have shown that most susceptible deposits have a high compressive and shear strength in the dry state. However, upon saturation, the chemical and physical bond between particles is diminished and the soil structure collapses. Where water has been ponded on such soils, spectacular cracks and sinks have developed.

Several areas within the San Joaquin Valley were delimited in which the California Aqueduct would cross hydrocompactible deposits. The length of canal lying within these areas aggregated 96 miles.

Subsidable areas were identified by means of aerial reconnaissance, examination of aerial photos, and field inspections. Interviews with local farmers also proved to be fruitful. Although in some instances the manifestations of subsidence had been obliterated by cultivation, the farmers often were able to recall and identify areas that had been affected.

Where the Aqueduct passed through susceptible soils, drilling was conducted at intervals to log the soil profile and to obtain samples for testing. Because the significant physical characteristics of these samples would be altered by wetting, it was necessary to substitute compressed air for drilling mud. Holes were drilled to depths up to 330 feet. Test plots were constructed on the alignment to confirm the findings of the field and laboratory studies and to investigate subsidence potential at specific locations in greater detail.

As discussed in Volume II of this bulletin, potential subsidence related to hydrocompaction (shallow subsidence) in areas traversed by the Aqueduct was treated by deliberately saturating the subsoils, allowing most of the subsidence to take place by hydrocompaction prior to excavation of the canal prism.

Oil and Gas Production. There are 493 oil fields located within the State of California. Subsidence due to oil production has occurred at 27 of these, ranging from a maximum of 28 feet at Wilmington field near Los Angeles to a few inches at others.

The California Aqueduct crosses 6 producing oil fields and passes within 1 mile of 11 others. Although, to date, no significant depressions have been detected in fields nearest the Aqueduct, a few inches of subsidence has been noted in the vicinity of Stockton, which is attributed largely to deflation of peat deposits but is possibly in part influenced by gas production. Oil exploration continues in parts of the San Joaquin Valley, and the possibility of discovering new pools beneath the canal must be considered.

Possibilities of future subsidence due to oil extraction have been discussed with major California oil producers. They are aware of the potential effects on the Aqueduct and have stated their intentions to plan their oil field operations accordingly. Monitoring of the profile of the California Aqueduct by periodic leveling surveys continues. It is proposed to extend these surveys to include bench marks located near the centers of oil production to detect the earliest manifestations of subsidence, thereby providing maximum lead time in which to implement corrective measures should they become necessary.

Tectonic Activity. Tectonic activity is the natural movement of the earth's upper crust related to the processes of mountain building and regional depression. Such deformations may take place rapidly during earthquakes and be manifested by offsetting along faults, regional tilting, uplifting, or down-dropping. On the other hand, tectonic movements may be so slow as to be imperceptible when measured over the life span of most man-made structures.

There is abundant evidence of regional tectonic activity in the Tehachapi Mountains and Transverse ranges. Gravel terraces, rejuvenated stream channels, and dissected alluvial fans indicate that some of this deformation has occurred during geologically Recent time (the past 10,000 years). High seismicity of the Tehachapi region confirms that such activity is continuing.

Because of the great length and gentle gradient of the Aqueduct, its carrying capacity could be affected by gradual tectonic distortion. Those segments in proximity of San Andreas and other active faults were recognized as the most vulnerable. A sequence of past leveling surveys along, and in the vicinity of, the Aqueduct was examined for evidence of potentially damaging strain. Seven tripartite tiltmeters also were installed at selected locations to measure crustal distortions on the order of magnitude of the earth tides (Figures 49 and 50). Neither surveys nor tiltmeters disclosed significant deformations.

The possible effects on the Aqueduct of tectonic movement was accepted as an intangible risk, the extent and frequency of which cannot be predicted with available technology. Other California aqueducts, which have been in operation from 25 to 50 years, have not suffered significant impairment from tectonic distortion.

Seismology

Objectives of the Department's seismic program were to assist in identification and evaluation of earthquake-related hazards to which the Project would be exposed, to develop criteria for the location and design of earthquake-resistant facilities, and to provide for earthquake alerting. Goals of these technical objectives, in order of importance, were public safety, reliability of water supply, and economy in construction and operation.

In the early stages of project planning, the field of earthquake engineering was in its infancy. At that time, only six severe earthquakes had been recorded by strong-motion seismographs and, consequently, the nature of the ground motions occurring near the source of an earthquake was poorly understood. Furthermore, the customary practice of basing the design of hydraulic structures on a pseudostatic seismic factor generally on the order of 0.05 to 0.1g was recognized as empirical. Accordingly, the Department of Water Resources met with representatives of the Earthquake Engineering Research Institute, a nonprofit organization dedicated to the improvement of earthquake design. On recommendation of that group, a five-man consulting board for earthquake analysis was created consisting of recognized authorities in the fields of geology, seismology, soil mechanics, foundation engineering, and structural engineering. This board has been used extensively throughout the design and construction period of the Project. Its recommendations are mentioned in Volumes II, III, and IV of this bulletin.

An Earthquake Engineering Office was established to implement needed earthquake-related research and studies. Efforts of this office were devoted largely to (1) studying the habits of the San Andreas fault, (2) developing design earthquakes for planning and design purposes, and (3) installation and operation of a seismograph alerting system. This system locates the epicenters of earthquakes throughout the State, measures their magnitude and, in the case of severe earthquakes, assures rapid dispatch of repair crews. Accordingly, all facilities of the State Water Project are covered.

Details of the research and special studies conducted by the Earthquake Engineering Office were published in the Department's Bulletin No. 116-4, "Earthquake Engineering Programs", May 1968. Programs which are continuing pertain to the State Water Project and are summarized below.

Seismic Surveillance Program

A sensitive seismic network was established by the Department in the 1960s and has been expanded to cover most of California. Seismographs were installed at selected sites to detect ground movements. Seismograms are telemetered to a central recording and analysis facility located in Sacramento in the Department's Earthquake Engineering Office (Figures 51, 52, and 53). This service provides (1) a reporting of all California earthquakes of magnitude 5 and greater, and (2) a history of seismic events occurring near State Water Project facilities. Included in the network are stations of other agencies operating in California and Nevada. The other agencies are the University of California at Berkeley, the California Institute of Technology, the U.S. Geological Survey, and the University of Nevada.

Strong-Motion Measurements

A network of strong-motion seismographs was established consisting of more than 60 instruments located on or near facilities of the State Water Project. Future strong earthquakes are expected to actuate these instruments and provide records of ground movement and the response of structures to that movement. These records will be analyzed to provide criteria for design of future structures.

At Oroville, Castaic, and Perris Dams servo-accelerometers, dynamic stress cells, and pore pressure cell arrays were embedded in the embankments to measure response of the fills to severe earthquakes. Servo-accelerometer arrays also were embedded in several pumping plant structures. Instrumentation of dams and other structures is discussed in more detail in Volumes III and IV of this bulletin.

Geodetic Surveys

Another program initiated by the Department of Water Resources, but now being continued by the Division of Mines and Geology, is a geodetic network extending from San Francisco Bay south to Palm Springs. It was designed to monitor the accumulation of strain and creep along the San Andreas and its tributary faults, including the Hayward, Calaveras, Garlock, White Wolf, San Jacinto, and Big Pine faults.

Geodetic surveys were commenced in 1959 by the Department utilizing the Model 2A optical geodimeter (Figures 54, 55, and 56). These surveys were designed to measure distances between stations sequentially sited on alternate sides of the fault throughout its length. Stations generally were located on mountain peaks or topographic high points 8 to 20 miles apart. The rate of strain build-up along these principal faults was determined by comparing the changes in line lengths that occurred over a period of successive measurements.

Figure 49. Tiltmeter at Cedar Springs Dam

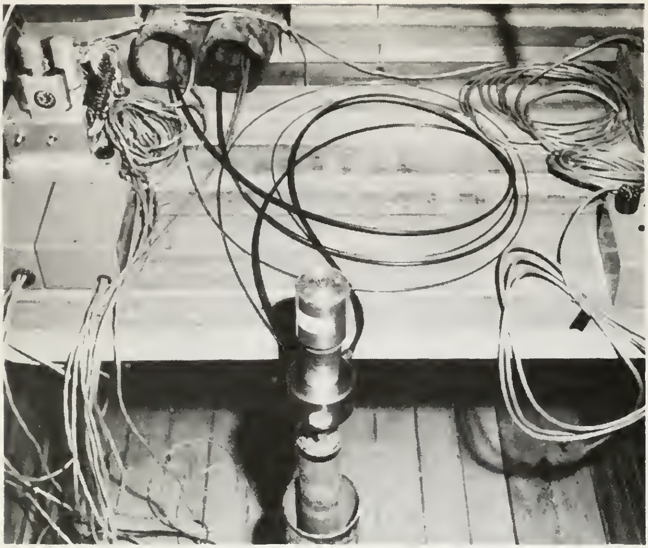


Figure 50. Tiltmeter Recording—Head Installation

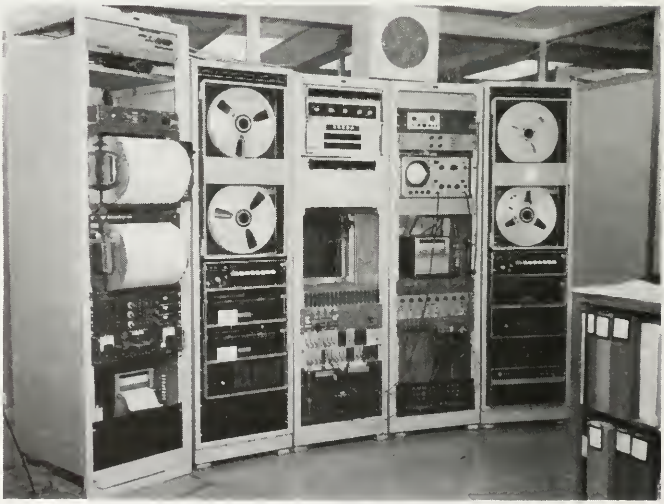


Figure 51. Seismic Recording Center—Sacramento

Figure 52. Seismic Film Recorders—Sacramento

Figure 53. Seismic Data Analysis—Sacramento

Figure 54. Geodimeter and Survey Crew

Figure 55. Geodimeter Light Transmitter

Figure 56. Geodimeter Reflector

CHAPTER VI. FEATHER RIVER FISH FACILITIES

General

Location

The Feather River Fish Facilities are located directly across the Feather River from the City of Oroville. The Fish Barrier Dam is located on the River approximately one-quarter mile upstream from the old Oroville-Chico truss bridge. The site of the Feather River Fish Hatchery is approximately one-quarter mile downstream from the bridge (Figure 57).

Purpose

Since Oroville Dam presents a barrier to the upstream migration of salmon and steelhead, facilities were constructed by the Department of Water Resources to compensate for the spawning grounds which would no longer be accessible. The life cycle of these anadromous fish prior to the State Water Project, during the interim stage of hatchery construction, and in the completed Feather River Fish Facilities is shown on Figure 58.

During construction of Oroville Dam, fish were diverted into an interim trapping facility by the Fish Barrier Dam. They were then anesthetized and transported by truck to a reach of river 6½ miles upstream from the Fish Barrier Dam and above the Oroville Dam construction site where they were released. From this location, the fish had access to natural spawning areas in the river gravels. Fingerlings migrated back downstream through the Oroville Dam diversion tunnels.

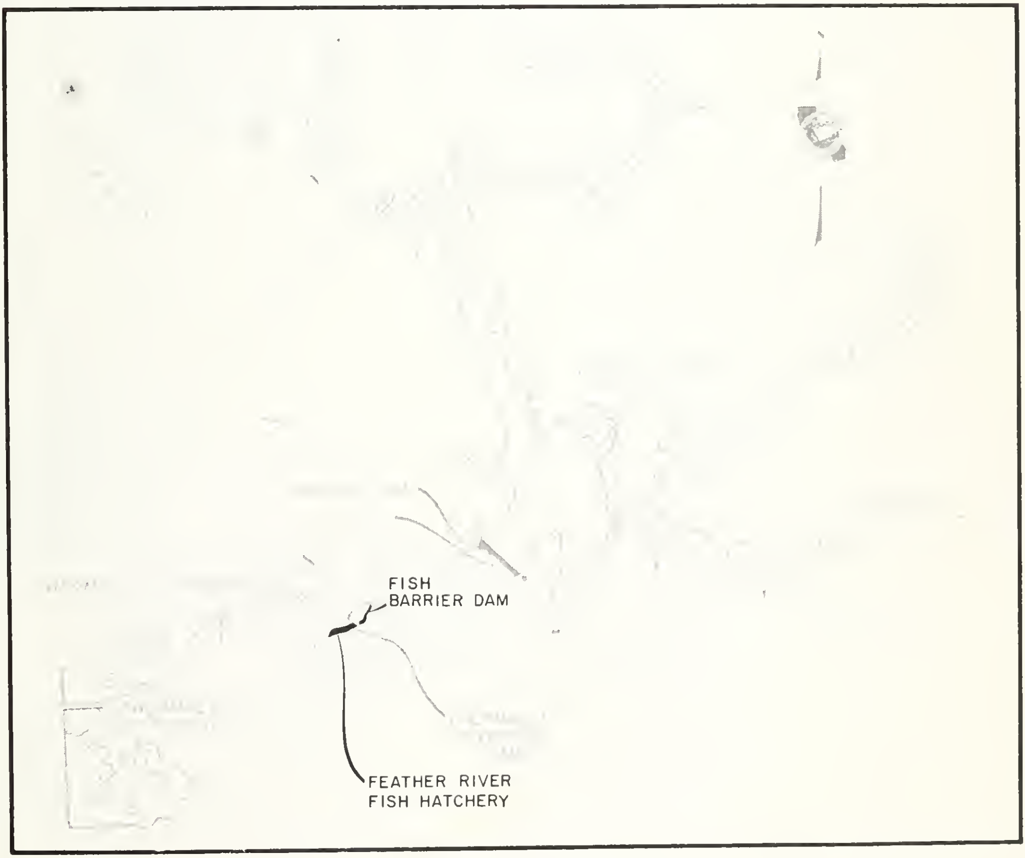


Figure 57. Location Map—Feather River Fish Facilities

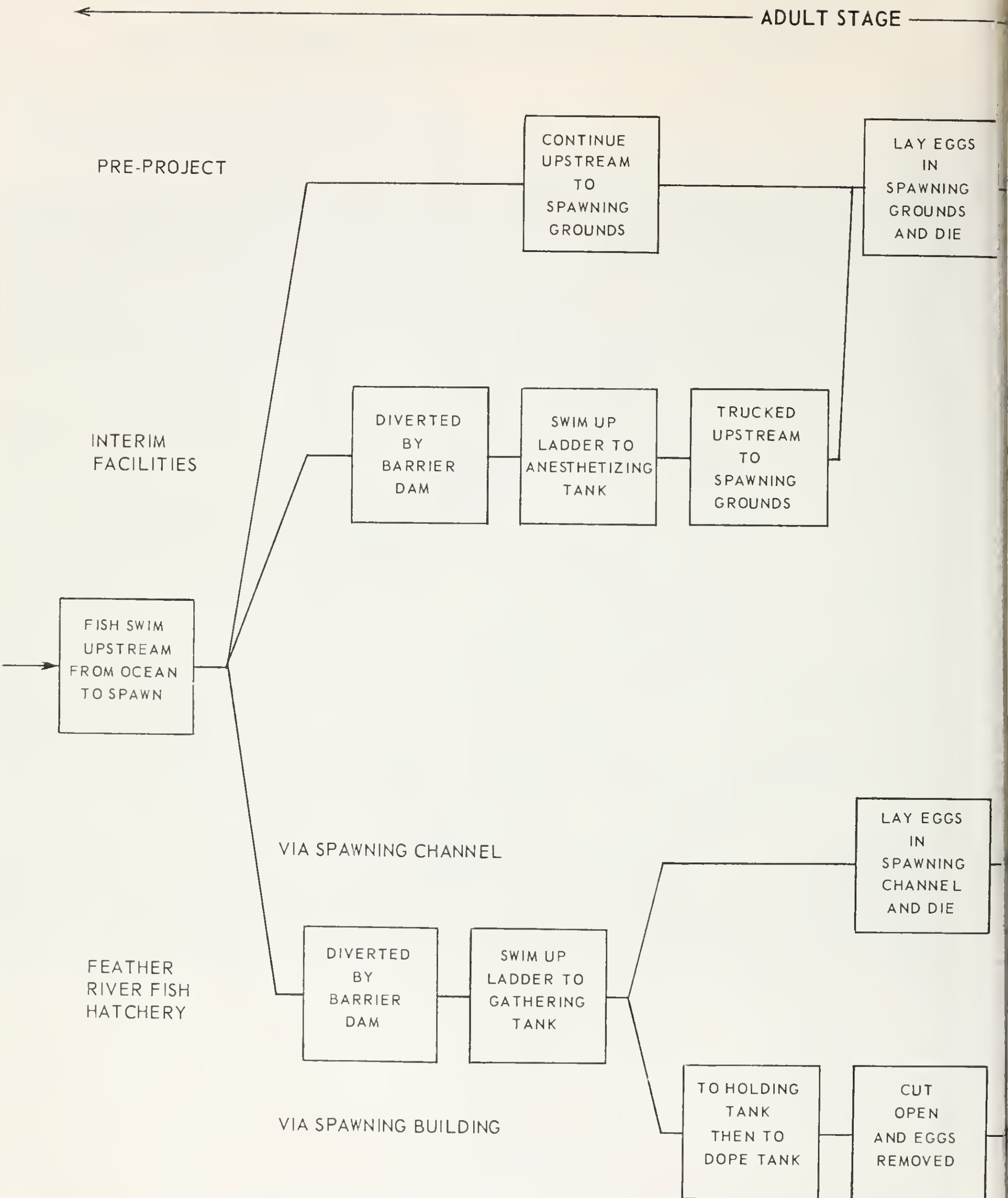
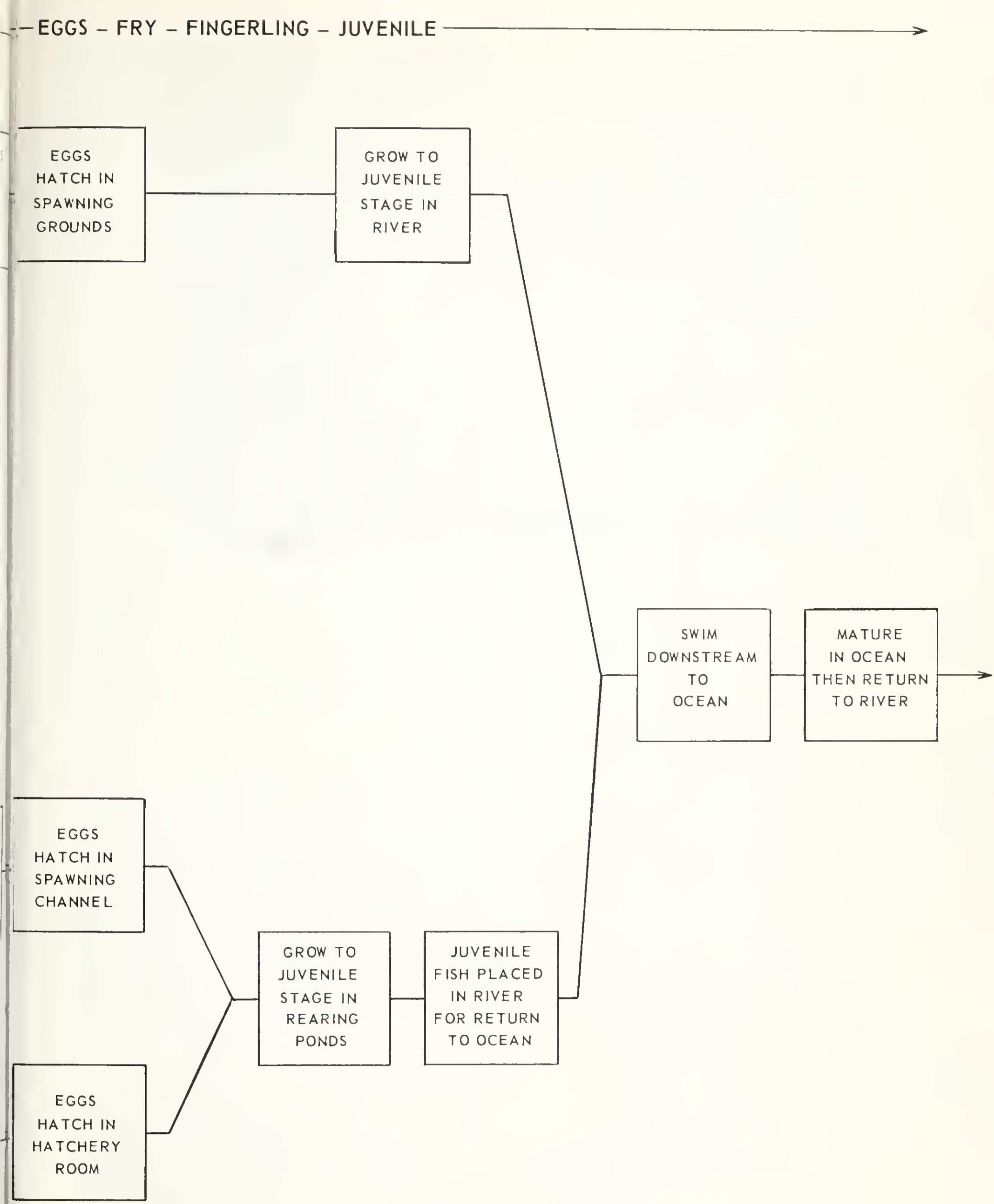


Figure 58. Life Cycle of Anadromous Fish


EGGS – FRY – FINGERLING – JUVENILE
EGGS HATCH IN SPAWNING GROUNDS
GROW TO JUVENILE STAGE IN RIVER
SWIM DOWNSTREAM TO OCEAN
MATURE IN OCEAN THEN RETURN TO RIVER
EGGS HATCH IN SPAWNING CHANNEL
GROW TO JUVENILE STAGE IN REARING PONDS
JUVENILE FISH PLACED IN RIVER FOR RETURN TO OCEAN
EGGS HATCH IN HATCHERY ROOM

The Fish Barrier Dam now diverts fish into a fish ladder which leads to the Feather River Fish Hatchery operated by the Department of Fish and Game.

Chronology

Preparation of designs, plans, and specifications for the Fish Barrier Dam and interim fish facilities started March 1961; construction began in April 1962 and was completed in May 1964. In March 1964, the first trout and salmon were trapped and hauled to a point above the Oroville Dam construction site. Preparation of preliminary plans for the permanent Hatchery began late in 1964. It was constructed between May 1966 and December 1967. In September 1967, the first salmon and steelhead trout entered the Hatchery.

Regional Geology

The geologic setting for the Fish Barrier Dam and Hatchery is the foothills on the western slope of the Sierra Nevada, a granite-cored, tilted, fault block. A series of tightly folded, steeply dipping, metamorphic rocks overlies the granite core along its western and northwestern flanks.

Geologic formations of the Oroville area are grouped into an older, steeply dipping "Bedrock Series", mostly dense, hard, metamorphosed volcanics and volcanic sediments, and a younger, overlying "Superjacent Series" of nearly flat-lying, nondeformed sediments and volcanic flows. For a more thorough coverage of Oroville regional geology, see Volume III of this bulletin.

Design of the Fish Barrier Dam

The Fish Barrier Dam was designed as a concrete gravity section (Figure 59). The general characteristics of the Dam are shown in Table 1, and the area-capacity curves are shown on Figure 60. The right section of the Dam (approximately 173 feet long) is nonoverpour. The remainder is of the overpour type designed to pass riverflows up to 200,000 cubic feet per second (cfs) without overtopping the nonoverpour section (Figure 61). Maximum controlled release from Oroville Dam is 150,000 cfs.

TABLE 1

Fish Barrier Dam
General Characteristics

Type	Concrete gravity
Crest elevation (nonoverpour)	181 feet
Storage capacity (gross)	580 acre-feet
Structural height	91 feet
Crest length	600 feet
Method of stream passage	Overpour spill section
Discharge capacity	200,000 cfs
Hydrology	Flow at the Dam is controlled by releases at Oroville Dam and Thermalito Diversion Dam

Riverflows below 45,000 cfs are confined to the low overpour section of the Dam for maximum effective fish attraction during the spawning season. Riverflows between 45,000 and 200,000 cfs are confined to the low overpour section and the normal overflow sections. The Fish Barrier Dam rating curve is shown on Figure 62.

The foundation of the Dam contains meta-andesite and meta-conglomerate rocks. Weathering extends to a considerable depth along planes of a well-developed joint system and shear zones, but rock between fractures generally is fresh and hard.

Overpour Sections

The central portion of the Dam in the river channel is a 250-foot-long, low overpour section (Figure 63) with the crest at elevation 148.5 feet. An apron extending downstream from the crest prevents fish from swimming or jumping upstream. The channel section is extended on each end by a conventional overflow section with the crest at elevation 163.0 feet along a total length of 176 feet.

The crest and apron of the low overpour section were considered as a reinforced concrete unit and were designed to resist heavy static and impact loads. These loads acting on the cantilevered apron induce high tensile forces on the top surface of the apron and on the upper segment of the upstream face of the Dam. Maximum loads are produced by a riverflow of approximately 50,000 cfs. At higher riverflows, the apron becomes submerged and the effective load is reduced.

Design of the low overpour crest was predicated on (1) adaptability of the crest to the geometry of the gravity section selected for stability requirements, (2) hydraulic considerations involved with discharge of large river floodflows, and (3) limitations set by the Department of Fish and Game for effective prevention of upstream fish migration. It was recognized that any crest section would operate with impaired efficiency due to the downstream projection of the apron required for fish containment; therefore, a composite crest section was chosen to simplify forming during construction. The crest adopted for both overpour sections approximates a broad weir with a circular arc forming the top.

Nonoverpour Section

The nonoverpour section on the right abutment of the Dam has a crest elevation of 181 feet and a total length of 173½ feet. The crest of the nonoverpour section was designed to accommodate maintenance vehicles and is provided with curbs and handrails for safety purposes.

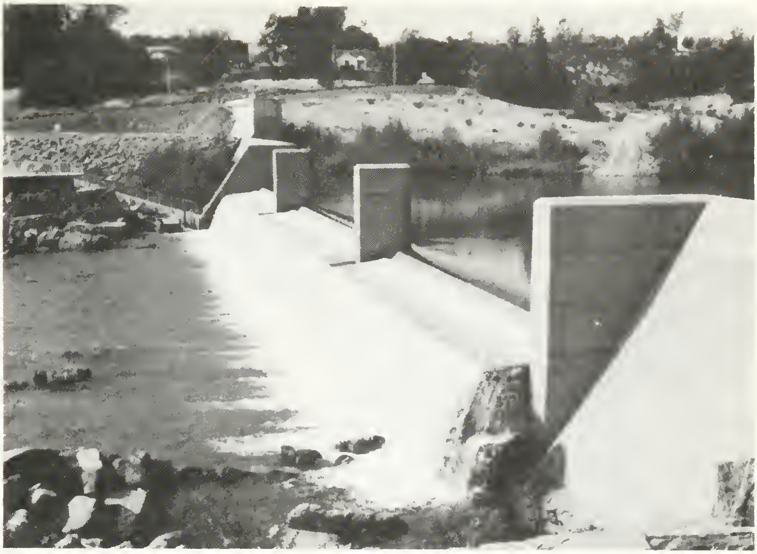


Figure 59. Fish Barrier Dam

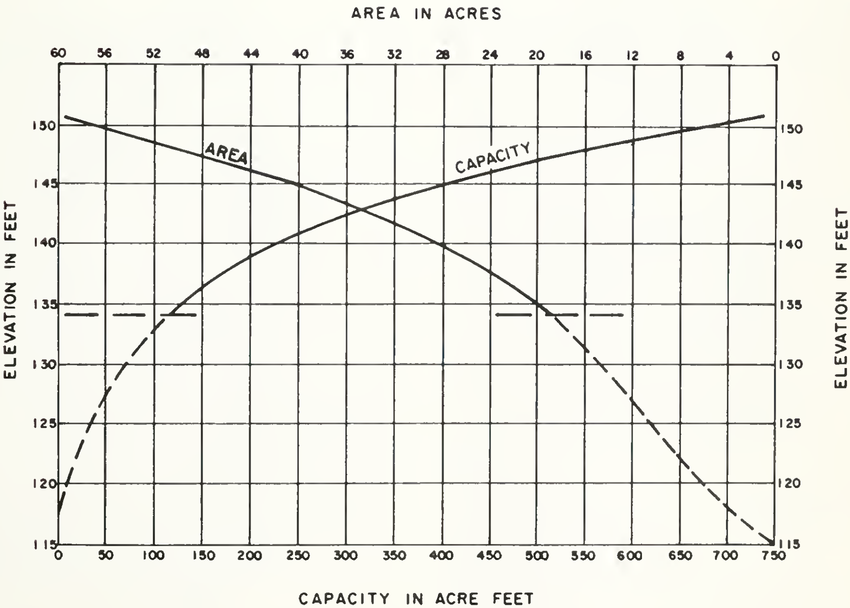


Figure 60. Fish Barrier Dam Reservoir—Area-Capacity Curves

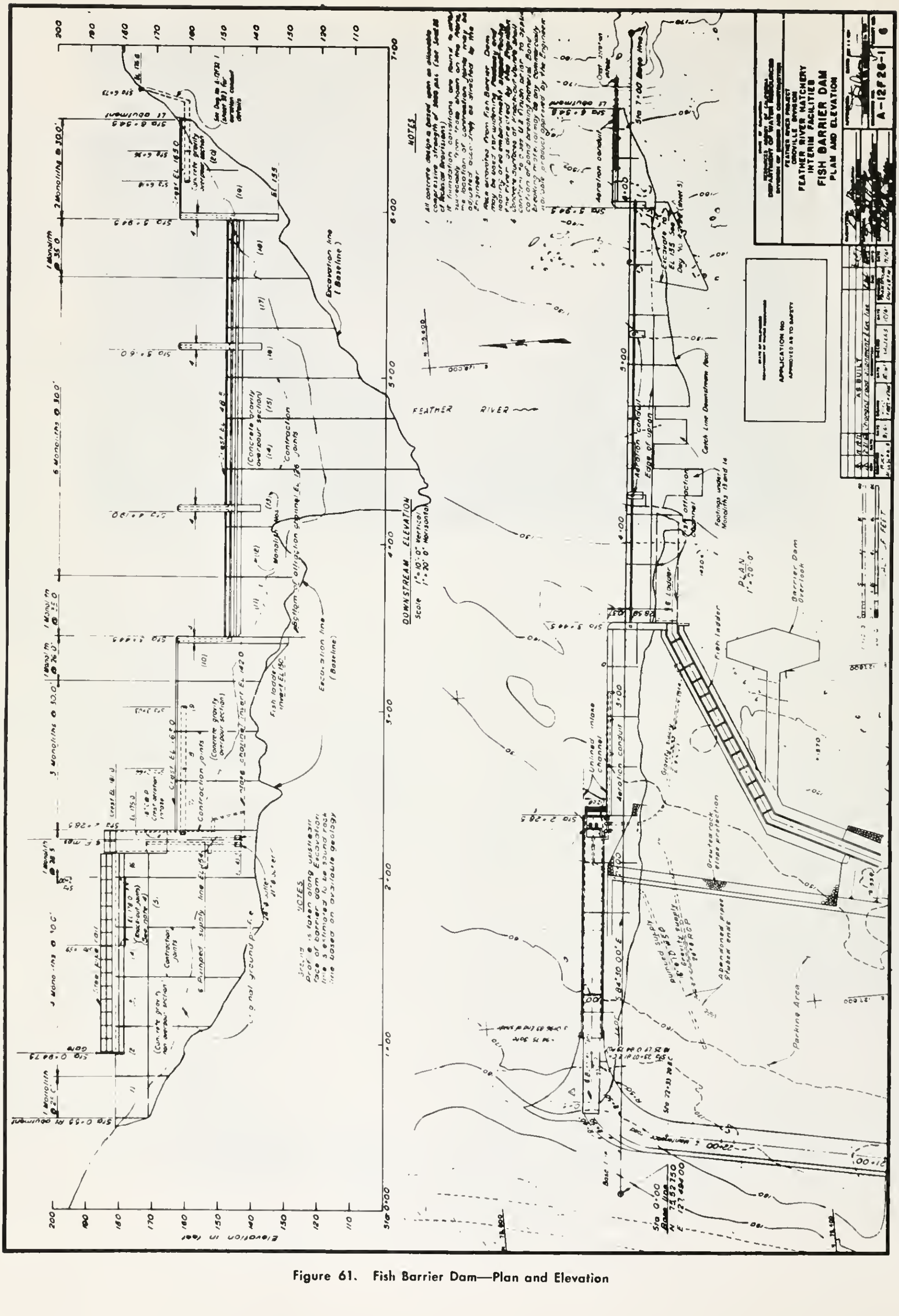


Figure 61. Fish Barrier Dam—Plan and Elevation

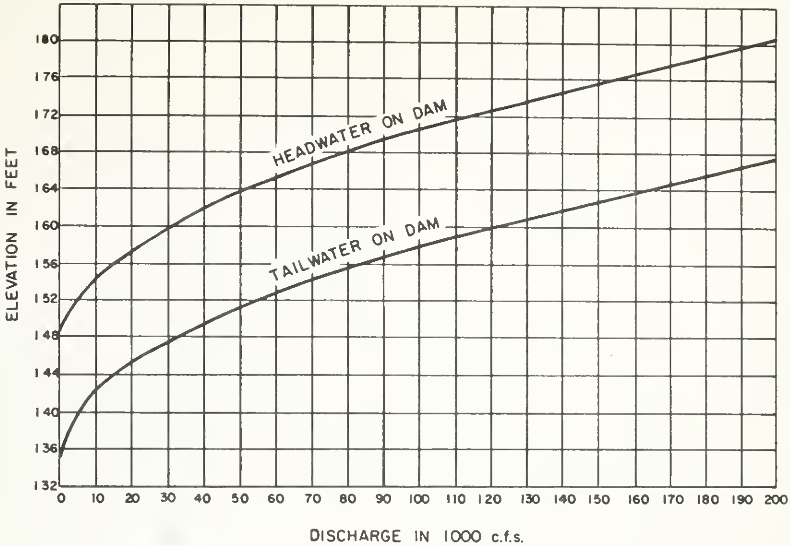


Figure 62. Fish Barrier Dam Rating Curve

Stability

Stability analyses were performed on various base levels, including the foundation level. Water surface profiles were computed for the crest overflow to determine the hydrostatic loads at, and downstream from, the crest. For stability analyses, water was assumed as flowing at critical depth over the crest. Momentum effect of the water jet upon the apron also was considered for the analysis of the low overpour section.

Silt load was combined with hydrostatic pressure on the upstream face. The silt load was considered effective to the top of the Dam on the low overpour section. Silt loads for sections other than the low overpour section were found to be negligible. Also, it was assumed that silt load was not imposed upon the downstream face of the Dam.

The most severe condition for the overpour section was found to be a seismic acceleration coefficient of 0.1g acting upstream. For the nonoverpour section, a seismic acceleration acting downstream with low river stage was the most critical condition. Dynamic water pressures were determined by Westergaard's formula assuming the natural period of the structure to be approximately one second. Intensity of uplift pressure was considered and was assumed to vary linearly from head water pressure to tail water pressure acting over 100% of the base.

Analysis for sliding on the foundation indicated that the allowable sliding factor (ratio of total horizontal forces to total vertical) of 0.70 is exceeded by 20% for the most critical loading conditions without seismic loading and is exceeded by as much as 57% when seismic loads are applied. It was determined, however, that the irregular nature of the foundation as excavated, together with bearing on the rock at the toe, would effectively resist sliding on the foundation. In addition, the shear-friction safety factor exceeded 4.

Compressive stresses in the Dam are considerably below allowable under all conditions of loading. Analysis did not indicate any tension (due to combined stress) in the Dam except at the toe of the nonoverpour section when river stage is at a minimum and seismic ground acceleration is assumed to act downstream. Tension in the latter exception, however, is below the allowable 60 pounds per square inch (psi) for seismic conditions.

Piers and abutments were designed using the same loading conditions as applied to the Dam, except that an impact load of 25% of the horizontal loads was assumed to act at the top of the upstream side of the piers.

Transverse contraction joints consist essentially of cold joints provided with 9-inch, synthetic rubber waterstops extending the full height of the Dam at the upstream face and across the apron in the low overpour section. Keyed transverse joints were not provided between adjacent monoliths of the Fish Barrier Dam, since it was deemed advisable to avoid stress transfer.

Aeration of Crest

Reduction of pressure at the trailing edge of the crest and under the apron, when overflow occurs, is a function of the head on the crest. Determination of the maximum aeration requirements is based upon the head corresponding to incipient submergence of the apron by the tailwater. Due to the nonconventional shape of the crest, an accurate determination of the air requirements was not possible. Complete aeration was not considered feasible due to the large quantity of air required. A maximum reduction in pressure of 5 feet of water was selected.

Aeration of the trailing edge of the low overpour crest is achieved by providing a formed 18-inch-diameter, vertical conduit in the piers and abutments. The bottom of the conduit is connected to formed, 12-inch-diameter, horizontal outlets, the extremities of which are flush with the pier or abutment and located in the area to be aerated (Figure 63).

Aeration of the space under the apron of the low overpour section is obtained by providing a formed rectangular opening through the apron at the downstream face of each pier. Except during high floodflows, the opening will not be submerged due to the contraction of flow around the piers.

Aeration of the high overpour section is accomplished by providing an 18-inch-diameter formed conduit within and parallel to the crest. This conduit is connected to 12-inch-diameter formed outlets at suitable intervals along the downstream side of the crest. Intake air supply is obtained by connecting the crest conduit with corrugated-metal, vertical, riser pipes—one placed in the right abutment of the Dam and one placed in the left abutment.

Design of Interim Facilities

Access Road

During the interim period of operation, an access road accommodated trucks required to transport the fish from the loading area at the Fish Barrier Dam to the release sites upstream from the Oroville Dam site. This access road now is used as an exit from the public parking area near the Barrier Dam.

Fish Loading Area

The fish loading area was the key portion of the interim facilities. The holding tank and the headworks of the fish ladder were located here. The mechanized fish sweep in the holding tank picked up the trapped salmon so that they could be placed on a conveyor-type loader which emptied into a tank truck. The adult salmon were then trucked around the dam construction site and released into the Feather River. After spawning in the natural gravels upstream, the eggs then hatched and the fry made their way downstream through the diversion tunnels.

The fish loading area was designed to provide flexibility in fish loading and truck movements. Finished elevation of the area was established to be above all but maximum riverflows. This loading area now has been removed.

Maintenance Road

A maintenance road extending from the loading area to the right abutment of the Fish Barrier Dam provided access to the interim pumps on top of the Dam. The road joins the top of the right abutment of the Dam at grade and now provides access to the Dam from the permanent facilities.

Design of the Feather River Fish Hatchery

The general plan of the Feather River Fish Hatchery is shown on Figure 64.

Visitor Facilities

It was recognized early in preliminary planning that a fish hatchery of this magnitude would generate much public interest. Therefore, layout and design of this facility were directed toward public viewing of the complete process of the hatchery operation. The entire site was oriented to safe, self-guided touring.

To accommodate the visitors, special facilities were provided in the design. These include a 273-car parking area; two comfort stations; a viewing platform near the Fish Barrier Dam; viewing windows into the fish ladder, spawning room, and hatchery room; viewing access to the spawning channel, holding ponds, and rearing ponds; and several visitor-activated, informational, tape-recording stations (Figure 65).

Fish Ladder

The homing instinct of anadromous fish is used to draw them from the River to the trapping facilities. The fish ladder,a concrete-lined channel, is the means of conveyance.

Raw water, drawn from the Thermalito Diversion Dam reservoir pool, is introduced at the headworks of the ladder and allowed to fall in a series of pools, created by weirs, to the outlet at river level. There is a drop in elevation of about 38 feet in the 2,150-foot-long ladder (Figures 66 and 67).

During the interim period of operation, two of the three water supplies for the fish ladder were pumped by a 10-cfs pumping plant located in the nonoverpour section of the Fish Barrier Dam. When Thermalito Diversion Dam was completed, the need for the two pumped supplies was eliminated, and all fish attraction water is now delivered by gravity.

When the interim gathering facilities for the Hatchery were constructed in 1964, the portion of the fish ladder adjacent to the Fish Barrier Dam was aligned to run under a proposed embankment for an alternate Oroville Dam construction haul road. However, the dam construction contractor chose not to use this haul route over the ladder and instead ran railroad tracks across the River downstream of the interim facilities (Figure 68).

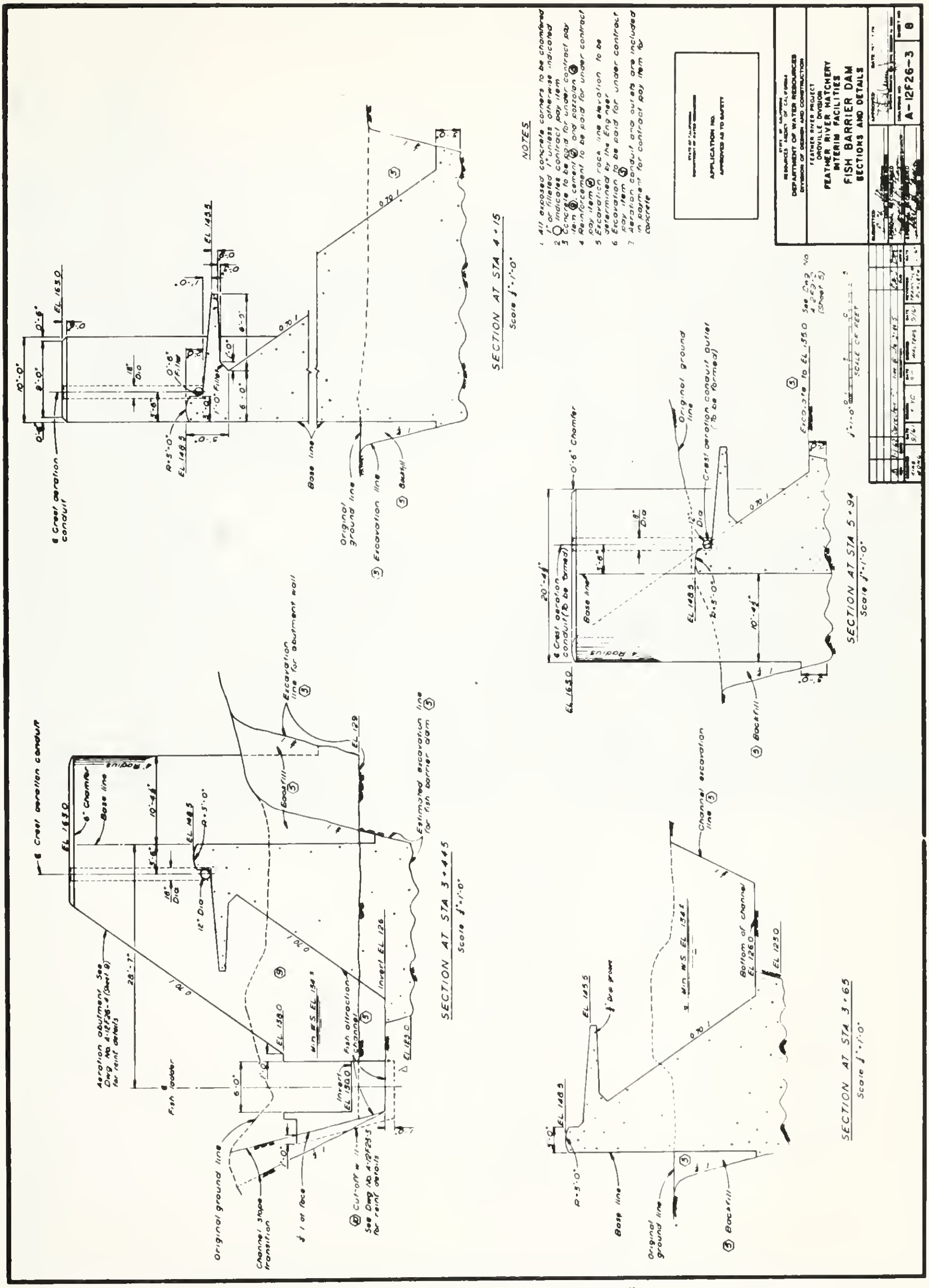


Figure 63. Fish Barrier Dam—Sections and Details

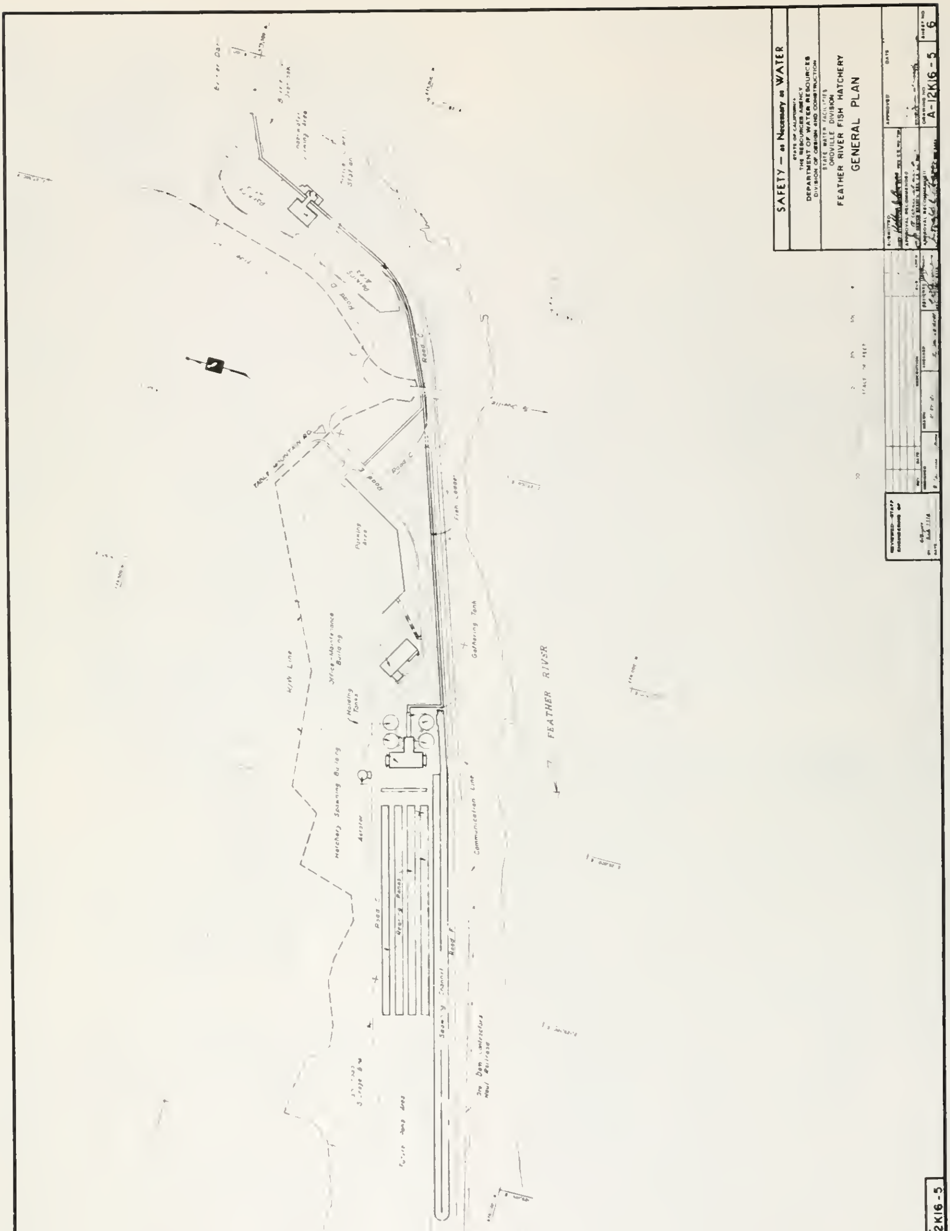


Figure 64. General Plan of Hatchery

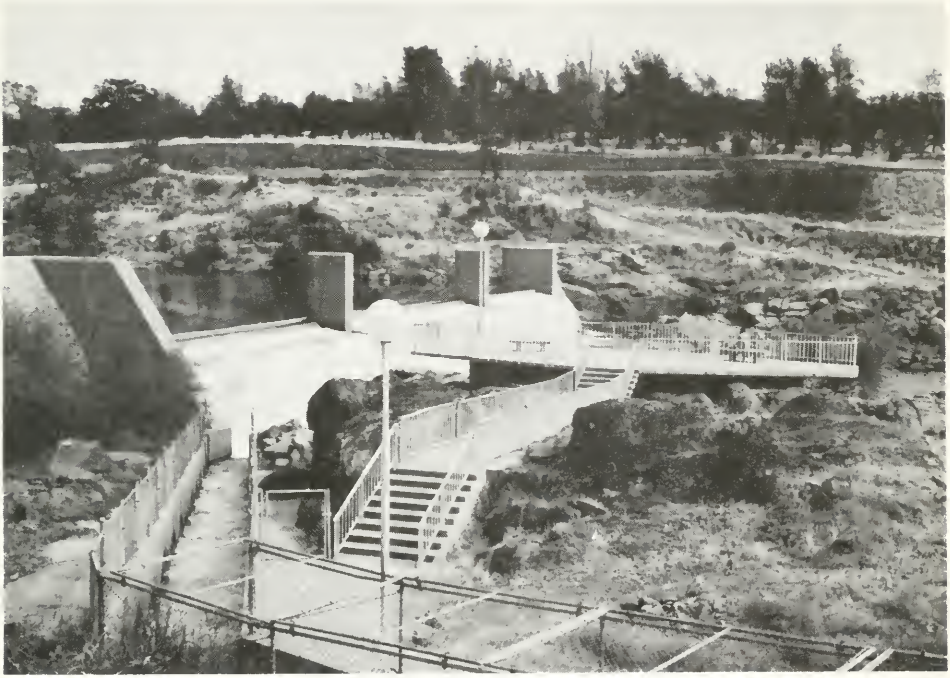


Figure 65. Observation Platform and Fish Ladder

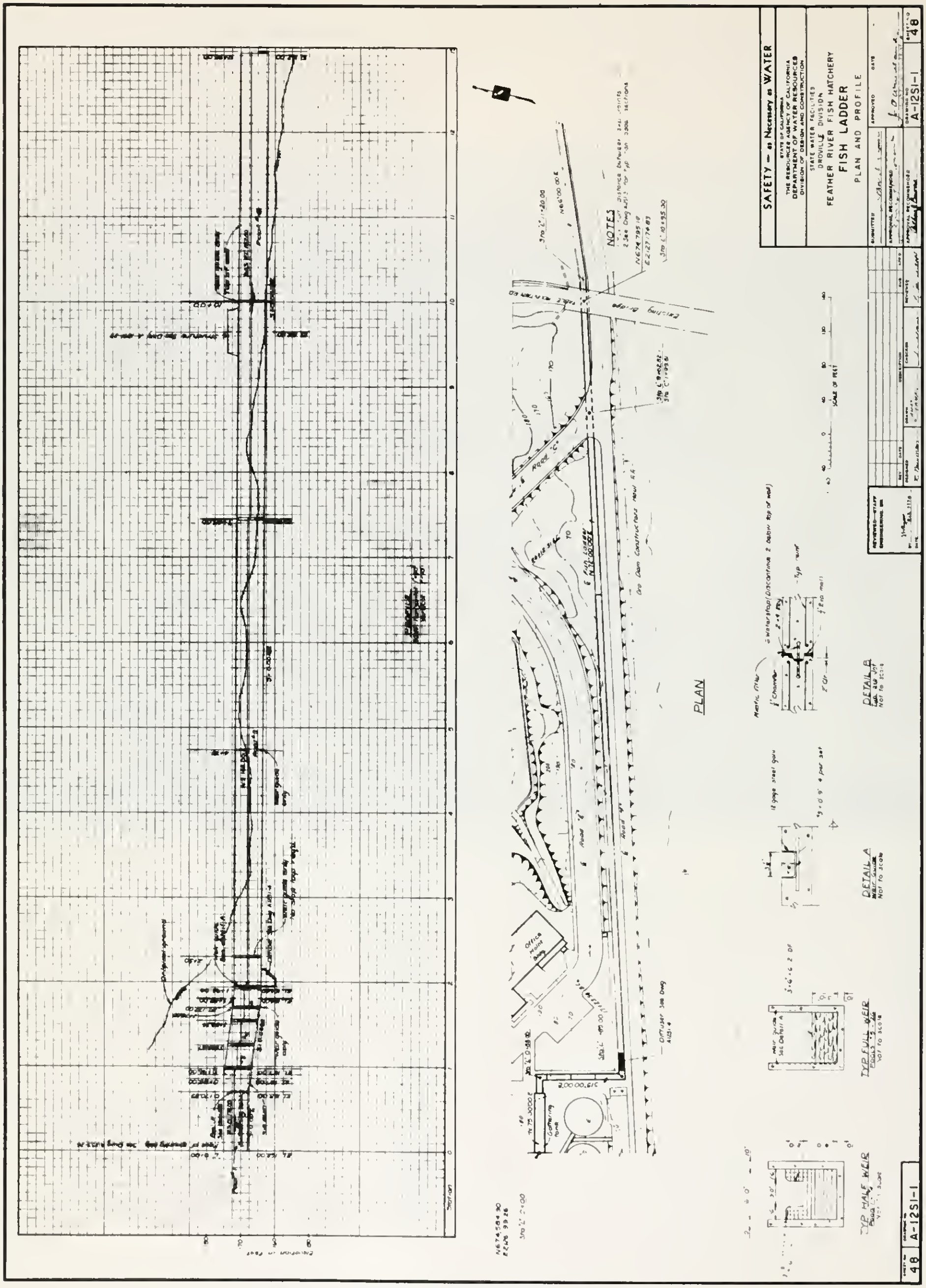


Figure 66. Plan and Profile of Fish Ladder (Upper Reach)

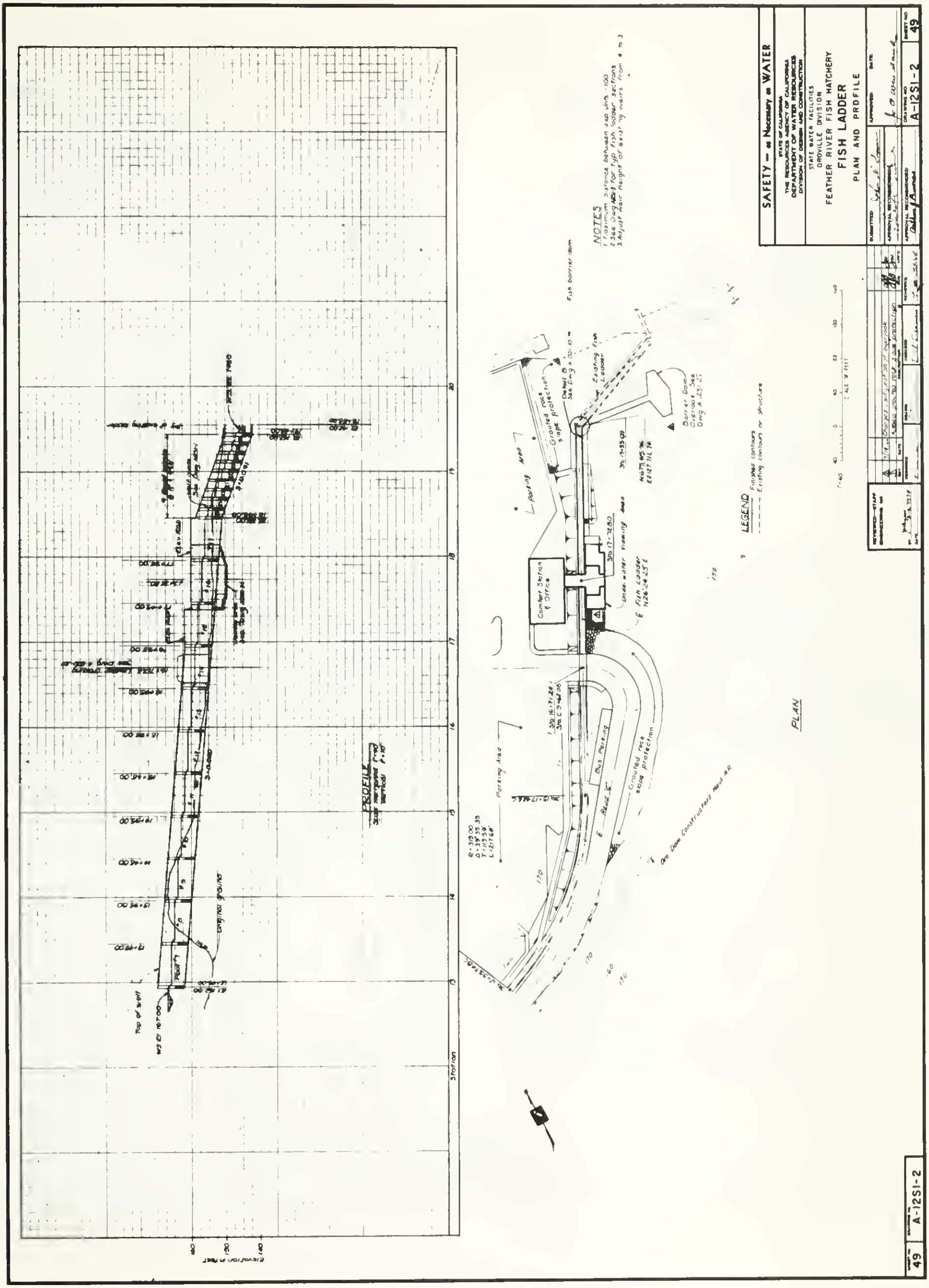


Figure 67. Plan and Profile of Fish Ladder (Lower Reach)

Figure 68. Barrier Dam, Interim Facilities, and Haul Railroad

The interim gathering tank and upstream portion of the interim ladder were abandoned and removed because they inhibited further development of visitor facilities on adjacent lands.

The new ladder alignment follows the toe of the landfill and intersects the earlier constructed ladder at a point approximately 130 feet from its outlet to the River.

Design. Design requirements for the fish ladder were:

Minimum width: 6 feet
Minimum water depth: 2 feet
Pool length: 8 to 1,000 feet
Weirs: Timber flashboards with or without submerged orifices
Velocity of flow in ladder: 2 to 5 feet per second (fps)
Maximum velocity of flow through diffuser: ½ fps
Difference in water surface elevations for adjacent pools in the immediate vicinity of the weirs must not be less than 12 inches nor exceed 15 inches

Timber baffle weirs were designed to limit the velocity of discharge to less than 3 fps for the normal operating range of ladder flows. Weir supports allow removal of the baffles for maintenance.

Stability. Alignment of the fish ladder is over foundation materials that subside at different rates under sustained loading. Therefore, a blanket of gravel was placed under the ladder foundation slab to minimize any abrupt changes and prevent localized rupturing of the concrete-lined waterway.

In addition, underdrain piping was installed along both sides of the ladder base to intercept and carry off subsurface water. This prevents the accumulation of water and resultant buoyant forces acting upon the ladder and also helps to maintain foundation stability of the adjacent asphaltic concrete pavement.

Underwater Viewing Area. The 42-inch-square viewing panels were installed in the wall of the fish ladder to afford the visiting public an underwater view of passing salmon and steelhead trout (Figure 69).

Gathering Tank. The gathering tank is an enlarged section of the fish ladder located at its upstream terminus. Its function is to entrap the fish ascending the ladder and, by means of a mechanical sweep, gather and deposit them into the abutting spawning building.

Holding Tanks and Header Flumes

Four concrete, circular, holding tanks are clustered about the spawning building to hold fish until they are ready for artificial spawning. These tanks are interconnected with the spawning building, gathering tank, and spawning channel by a network of concrete header flumes. By selective use of watertight panel gates, water supply outlets, and drains, a specific flow can be isolated and its direction controlled. By isolating the flow within each holding tank and forcing it into a tangential pattern, fish impounded in that tank are made to orient themselves into positions where they will be least likely to hurt themselves. By altering the direction of flow within the flumes, fish are induced to move of their own volition from the gathering tank into a specific holding tank, the spawning building, or the spawning channel. This means of moving anadromous fish is an exploitation of their natural homing instinct to swim upstream against water of their native stream.

Dope Tank Hoist

Female salmon, ripe for spawning, are heavily laden with well-developed eggs. It is essential that these fish be handled carefully to avoid external pressures that may expel prematurely the eggs from their bodies.

To prevent this egg loss, a hydraulic-operated lift within the receiving tank of the spawning room is employed. After the fish have succumbed to an anesthetizing solution, the tub mounted upon the hoist is raised to within the reach of the fish handlers. Thus, the fish arrive for the spawning operation in a cushion of water.

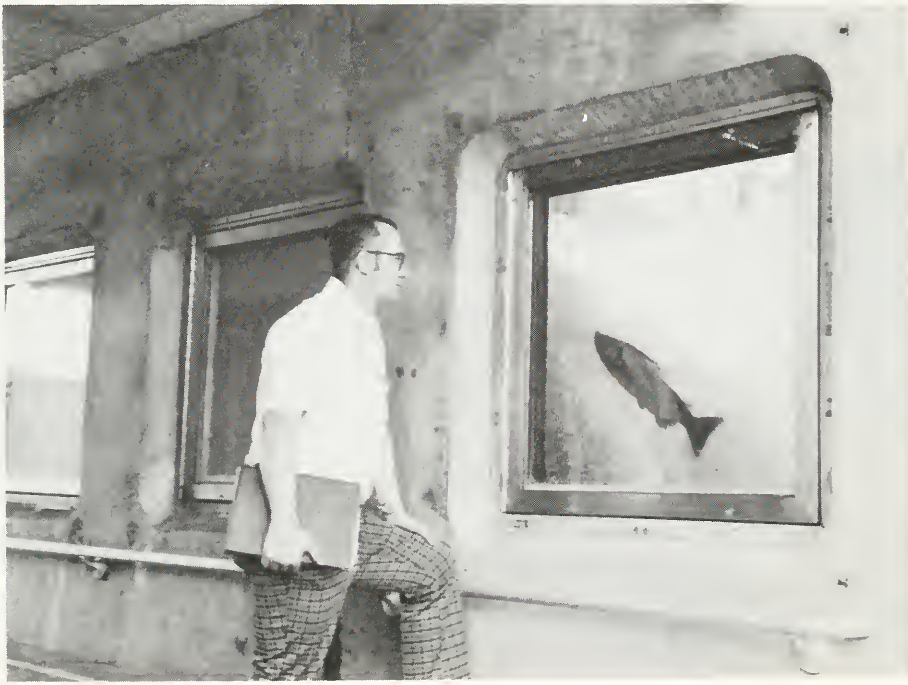


Figure 69. Fish Ladder Underwater Viewing Area

Hatchery-Spawning Building

The hatchery-spawning building is divided into two rooms (Figures 70 and 71), one for taking and fertilizing eggs from the adult fish and the other for hatching the eggs. There are viewing platforms and windows on each side of the building for the convenience of the visiting public.

Spawning Room. The spawning room was designed to sort steelhead from salmon and take and fertilize eggs from the ripe females. Females that are not ready to spawn are placed in holding tanks, and steelhead that arrive during the salmon run are returned to the River through the steelhead release, an open pipe adjacent to the dope tank.

The spawning process begins with killing the fish by striking them with a wooden mallet. This is necessary so that they may be handled and the salmon always die after natural spawning. The eggs are taken by slitting open the belly of the female and placing them in an incubator tray. They are then fertilized by "milking" a male of its sperm over the tray of eggs. The eggs are then hardened by covering them with cold water, and the trays are stacked for placement in the hatchery room. The dead adult salmon are placed in a walk-in cooler for storage and subsequent use by governmental institutions.

Hatchery Room. The hatchery room was designed to eliminate as much light as possible from the incubators because a darkened condition is required to hatch eggs. No windows are installed except for two viewing panels at each end of the room. These panels are sheltered with canopies and concrete block walls to block sunlight.

Spawning Channel

The spawning channel (Figure 72) is a ½-mile-long, concrete-lined channel filled with cobbles of a select gradation and simulates a spawning riffle in a natural stream. This method of hatching fish was in the experimental stage when the Hatchery was designed. It is used at this hatchery in conjunction with the more conventional, hand-stripping, incubator-hatching method. The new method was thought to require less manpower, equipment, and facilities than the conventional method. Additional land was made available for three future channels.

The Department of Fish and Game reports that, at present, the spawning channel is used only after the capacities of all other incubating and rearing facilities of the Hatchery are being utilized. The reason for this approach is that it has been found that hatchery raising of young fish to approximately twice the previous release size has accounted for a much higher return of adult salmon.

The spawning channel was not designed to rear fish. No provisions have been made to feed, sort, and segregate the fish. Furthermore, since it is quite difficult to net the fingerlings in the irregular cobble-bottomed channel, these fish would have to be released directly to the River soon after hatching.

Channel Lining. Originally, the channel lining was to be a 1-inch-thick blanket of impervious clay, 25

Figure 70. Hatchery-Spawning Building and Holding Tanks

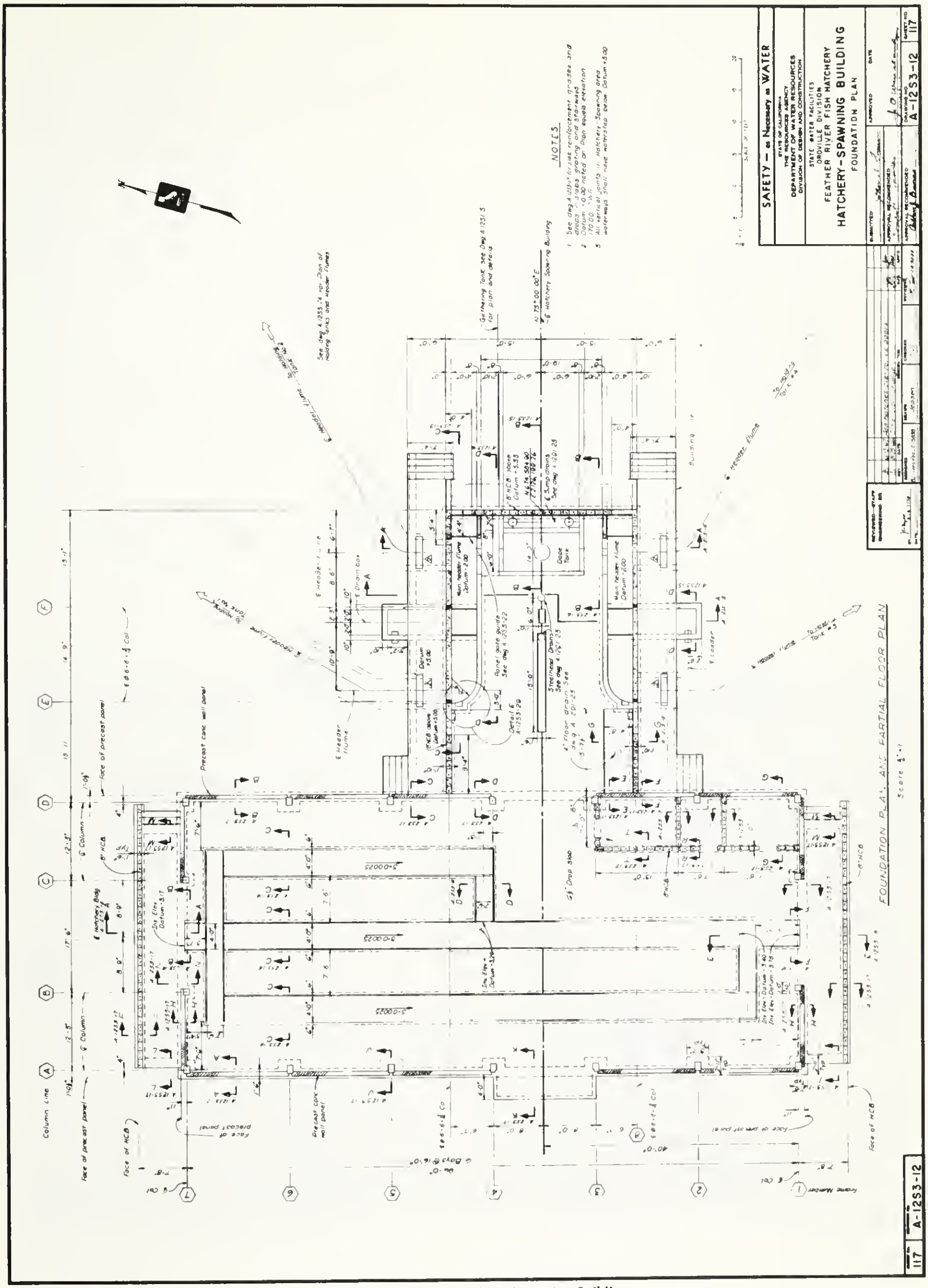


Figure 71. Plan of Hatchery-Spawning Building

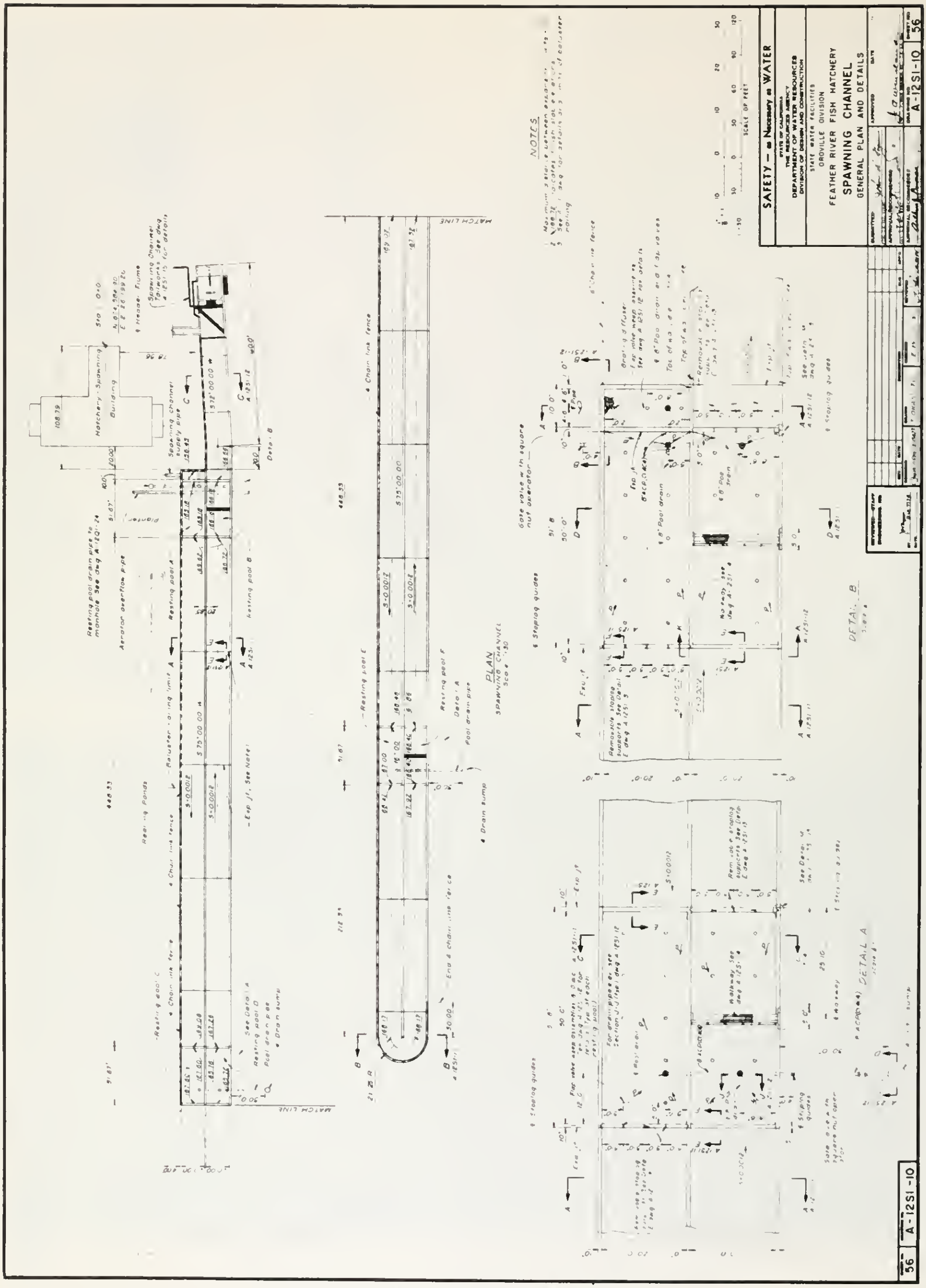


Figure 72. Spawning Channel

feet wide at the bottom, with the sides sloped for stability. However, because the possibility of flow-through with a clay lining is great and since tracked equipment periodically must enter the channel to reshape the blanket of spawning gravel (cobbles) disarranged by spawning fish, a concrete liner with a 20-foot width was substituted.

Resting Pools. Five-foot-deep resting pools are provided at 500-foot intervals throughout the length of the spawning channel. Two bar screen barriers are provided as an operational option to limit fish movement in case they voluntarily do not distribute themselves uniformly throughout the spawning channel.

Rearing Ponds

The 48 rearing ponds are concrete-lined raceways blocked off at intervals to form individual pools approximately 100 feet long and 10 feet wide. These ponds are contained in four pairs of raceways, each raceway containing six ponds (Figures 73 and 74). Dissolved oxygen content of the water fed to the ponds is controlled. The offspring of the artificially spawned fish are reared to the stage where they can be released from the rearing-pond raceway tailworks directly to the River for their migration to the ocean. Waterflow is maintained at 3 to 5 cfs in each pond with a velocity of approximately 0.1 foot per second.

After the Hatchery went into operation, it was evident that a warmwater supply for the rearing pond was necessary to inhibit the spread of Sacramento River Chinook disease (cold water virus) among the King salmon fry. An agreement was made in December 1969 whereby Thermalito Irrigation District supplies a 4-cubic-foot-per-second flow from its warmwater wells from January to May of each year. This water is aerated and mixed with Feather River water to obtain the desired 58 degree Fahrenheit temperature, thus helping to suppress the disease.

Rotary Screens. Electrically operated, self-cleaning, rotary screens have been installed at the lower end of each raceway to allow passage of waterborne algae, yet prevent the escape of fish.

Fish Screens. Aluminum perforated-plate screens have been provided to limit the travel of fish within the raceways. In addition to serving as demarcations for the individual rearing ponds, screens also have been provided to subdivide further these ponds into nursery areas and to facilitate fish trapping and grading operations. Screens vary in the number and size of their perforations.

The rearing pond raceways were designed to accommodate a self-propelled, fish grading apparatus which is planned for future use. Provisions were made to allow the complete removal of all screens, their

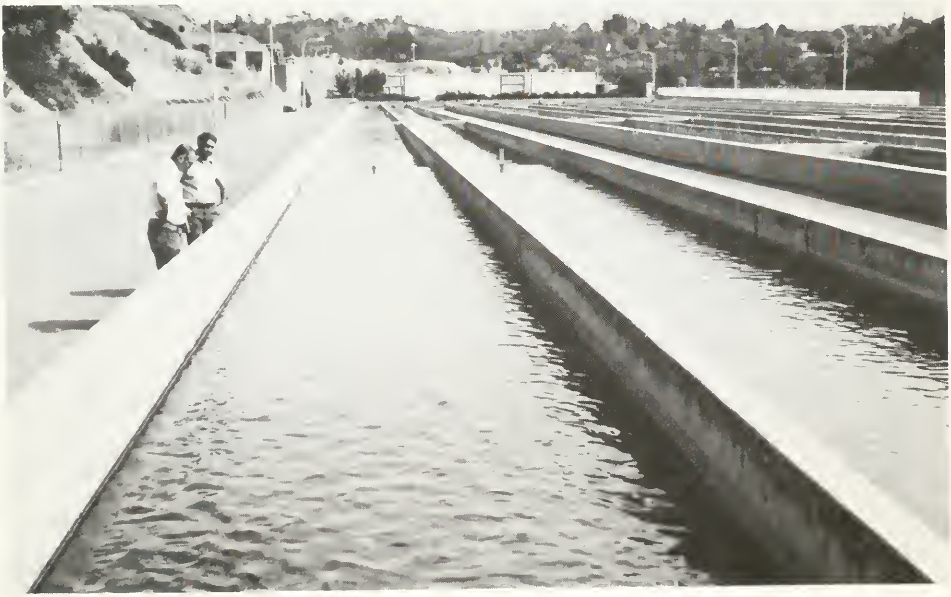


Figure 73. Rearing Ponds

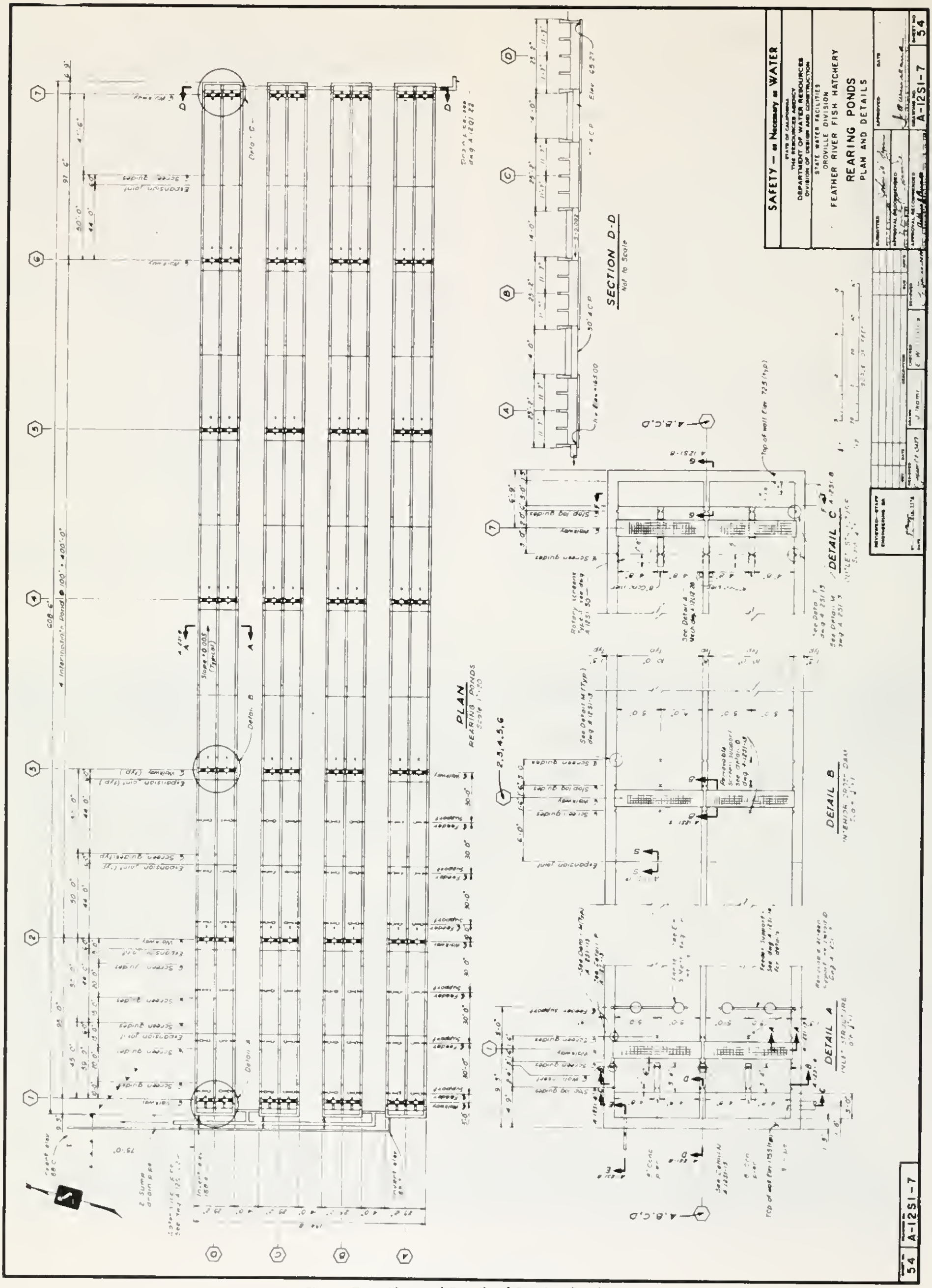


Figure 74. Plan and Details of Rearing Ponds

intermediate supports, walkways, and feeders in order to provide an unobstructed channel for the entire length of each raceway.

Fish Feeders. Fish in the first two upstream ponds of each raceway, being the most recently hatched, are fed by means of automatic feed dispensers uniformly spaced along the rearing pond walls. They are basin-type dispensers developed by the Department of Fish and Game. A modification of the supports allows the dispensers to be recharged with feed at the side of the pond and then swung back into position over the water.

Fish in the remaining four ponds of each raceway are more mature; therefore, they require a substantially larger volume of feed. They are fed fish pellets blown to them from a motor vehicle traveling alongside the raceway.

Fish Feed Storage

Initially, provisions were made for the storage of at least 60 tons of dry, pelleted, fish food. Approximately 45 tons were kept within four elevated, bulk-storage bins located near the northwesterly corner of the hatchery grounds. The remaining 15 tons were purchased in 50-pound sacks and stacked within the fish food storage room of the office-maintenance building. However, after the Hatchery was put into operation, construction of a 35-ton-storage-capacity, walk-in freezer for fish food was necessitated due to the Department of Fish and Game's changeover from dry fish meal to Oregon "moist" fish food. The freezer is 26 feet long, 14 feet wide, and 10½ feet high and located at the north end of the fish food storage room.

Aerator

During the first years after filling a new reservoir, such as Lake Oroville, decaying vegetal matter within its confines reduces the dissolved oxygen content of the water and introduces noxious gases. These two water conditions hinder the development of fish eggs and endanger the survival of young fry. It is essential, therefore, that water from Lake Oroville be aerated to increase its dissolved oxygen content and to dispel the noxious gases before introducing the water into the hatchery water distribution system. After this initial stage, the aerator will be used continually to supplement the dissolved oxygen content of the water supply from the Lake.

The aerator employed (Figure 75) is a cylindrical concrete structure, housing a water-dispersing, fixed-cone valve. A fan-shaped appendage near the front of the structure contains the separate water outlet chambers for distributing flows to the rearing ponds, spawning channel, hatchery building, and holding tanks.

Incoming water from Thermalito Diversion Dam enters the steel standpipe in the center of the aeration chamber and, upon leaving its open end through the dispersion cone, is forced into a spray. Thus, aeration is attained by exposing the increased water surface area to the atmosphere. Flow is measured by a 48-inch-diameter flow tube.

Water Disinfecting System

Soon after the Hatchery went into operation, a protozoan parasite (Ceratomyxa Shasta) was decimating the steelhead fingerlings. To reduce fatalities, an ultraviolet water disinfecting system was installed. Water for the rearing ponds is passed through three 8-foot-diameter, 22-foot-long, sand filters to remove sediment before being exposed to the ultraviolet light.

The ultraviolet (U-V) system was chosen over a chlorine disinfecting system because (1) it is more reliable, (2) chlorine must be eliminated entirely from the water before contact with the fish, and (3) the U-V system kills other microorganisms that might attack the fish.

The U-V system consists of 20 individual U-V water sterilizers, each passing 75 gallons per minute (gpm) over eight U-V tubes. This system also includes control panels for the individual U-V tubes, local and remote failure alarms, and light-intensity controls.

Water is circulated through the filters and U-V units by two 40-horsepower (hp) pumps, each delivering 800 gpm at 125 feet of head. The pumps and U-V equipment are located in a 40- by 20-foot metal building located at the west end of the facility, with the filters located behind the building to shield them from public view.

A 75-kW emergency generator also is located outside to provide power to the U-V system in the event of an electrical service interruption.

Raw Water Distribution Network

After hatchery inflow has been aerated, it is distributed directly to the rearing ponds, spawning channel, hatchery-spawning building, holding tanks, and gathering tank. Outflow from the spawning channel is directed into the fish ladder by way of a 36-inch pipe through a diffusion opening. This supplements the ladder flow and helps maintain the water level and temperature in the natural holding pool below the Fish Barrier Dam. The main flow for the ladder comes from flows through the gathering tank, which is directly connected to the ladder headworks. Outflows from the rearing ponds and the hatchery building drain into the sump at the spawning channel tailworks and then into a drain line to discharge into the Feather River.

To protect against interruptions in raw water flow to the Hatchery, an emergency recirculation system was incorporated into the raw water distribution network. In this emergency system, the combined outflows from the rearing ponds, hatchery building, and spawning channel automatically are pumped back

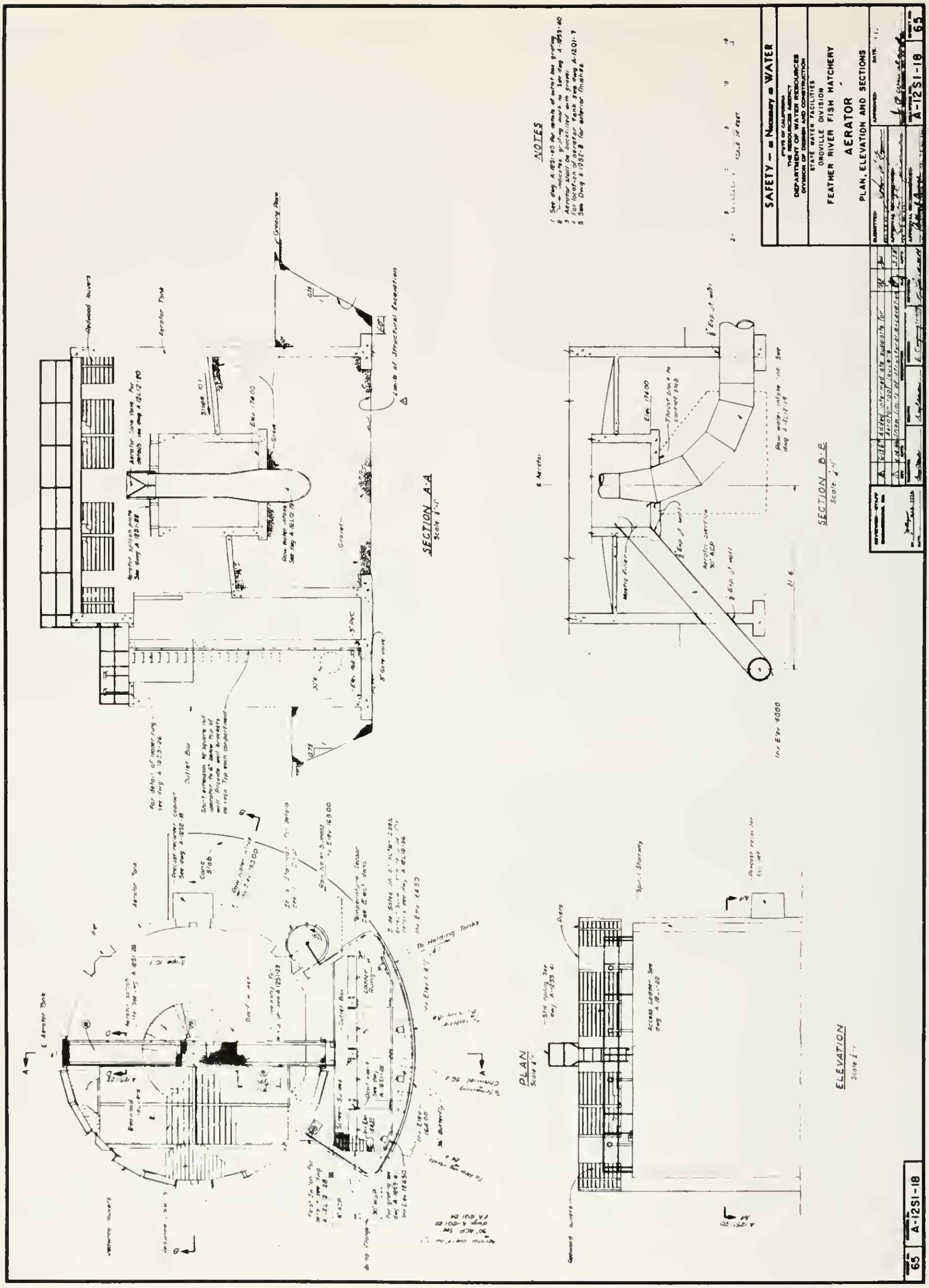


Figure 75. Aeratar

through the rearing ponds and the hatchery building by two 150-hp, 50-cfs pumps located near the discharge end of the spawning channel tailworks. The spawning channel is supplied only if there is sufficient water available after the requirements of the rearing pond and hatchery building are met.

The pumps also can be activated manually to recirculate the in-hatchery water whenever the Feather River supply contains a high concentration of suspended solids.

Electrical and Signal Systems

Electrical Power

Electrical service is supplied to the outdoor, Department of Water Resources-owned, unit substation (12 kV-480/277 volts, 3 phase) from the Pacific Gas and Electric Company 12-kV overhead distribution system.

Power is distributed to the various buildings via underground duct banks at 480 volts, 3 phase. Power for interior lighting and convenience outlets is derived from 480-120/208 volt, dry-type transformers located in the buildings.

Signal Systems

Communications System. Telephones are provided with a hold button and talk button. Incoming calls are taken in the office; other areas are then signalled by a buzzer.

Alarm Systems. Burglar alarms were provided by taut wire detectors to protect against illegal entry over fences and by photoelectric detectors at normal entrances, such as gates. Both systems were found to be ineffective and plagued with technical difficulties. Their use has since been abandoned.

Fire Alarm System. The fire alarm system consists of manual stations, automatic fire detectors, and alarm bells in two zones. In addition to local alarm bells, an alarm is transmitted to the Oroville Fire Department.

Plant Malfunction Alarm System. The plant malfunction alarm system consists of eight zones and monitors various functions in the Hatchery, such as water levels and power failures at key functions such as fish feeders.

Chlorine Sensor Alarm and Shutoff. Because of intermittent high chlorine content in the back-up raw water supply system, a chlorine sensor is provided which will initiate the closing of a valve in the line and initiate an alarm.

Construction of Fish Barrier Dam

Contract Administration

The Fish Barrier Dam and interim facilities of the Feather River Fish Hatchery were constructed under a single contract designated Specification No. 62-01. General information for this contract is shown in Table 2. The completed interim facilities are shown on Figure 68.

TABLE 2

Major Contract

Interim Facilities—Feather River Hatchery

Specification	62-01
Low Bid Amount	$1,096,700
Final Contract Cost	$2,116,293
Total Cost-Change Orders	$620,213
Starting Date	3/16/62
Completion Date	5/8/64
Prime Contractor	Frazier-Davis Construction Co.

Diversion and Care of River

The contractor diverted the River from the construction areas by using sheet-piling cofferdams comprised of circular cells and connecting arcs. Originally, the diversion scheme called for two stages of cofferdam construction. This was revised to include a third-stage cofferdam consisting of a single row of sheets supported by beams located at the upstream face of Monoliths 17 and 18. These two monoliths were then left 5½ feet below final crest elevation during second-stage construction, thereby increasing the cross-sectional area available for river diversion and making construction of the second-stage cofferdam much easier.

Layout of the cofferdam cells is indicated on Figure 76. Three cell diameters, 30 feet, 40 feet, and 50 feet, were used depending upon the estimated depth to rock at individual cell locations (with the larger-diameter cells being used at deeper areas). All cells were set with one template which was adjustable to the required diameters. After the sheets were set and driven to refusal with an air-operated hammer, the cells were dewatered and then filled with dredge tailings. The sheets were to have been trimmed and a 1-foot-thick concrete cap placed on top of each cell to prevent the fill from being washed out during overtopping.

Numerous problems were encountered in the placement of the cofferdams. To close cell 4 of the first-stage cofferdam (Figure 77), the last 15 sheets had to be dropped simultaneously because the water current was pulling individually placed sheets away from the template. When these 15 sheets were dropped, a differential head of 4 feet developed between the water surface level inside cell 4 and the level between cell 3 and cell 4, resulting in the failure of about 20 sheets of cell 4 (Figure 78).

The first-stage cofferdam was completed on October 5, 1962, with the exception that the sheets were not trimmed and concrete caps were not placed. The contractor deferred these items as he was anxious to get underway with dam construction.

Heavy rains that started on October 10, 1962 caused overtopping of the first-stage cofferdam about midnight on October 11, 1962. Flow crested at about 136,000 cfs at 6:30 p.m. on October 13, 1962. Cofferdam

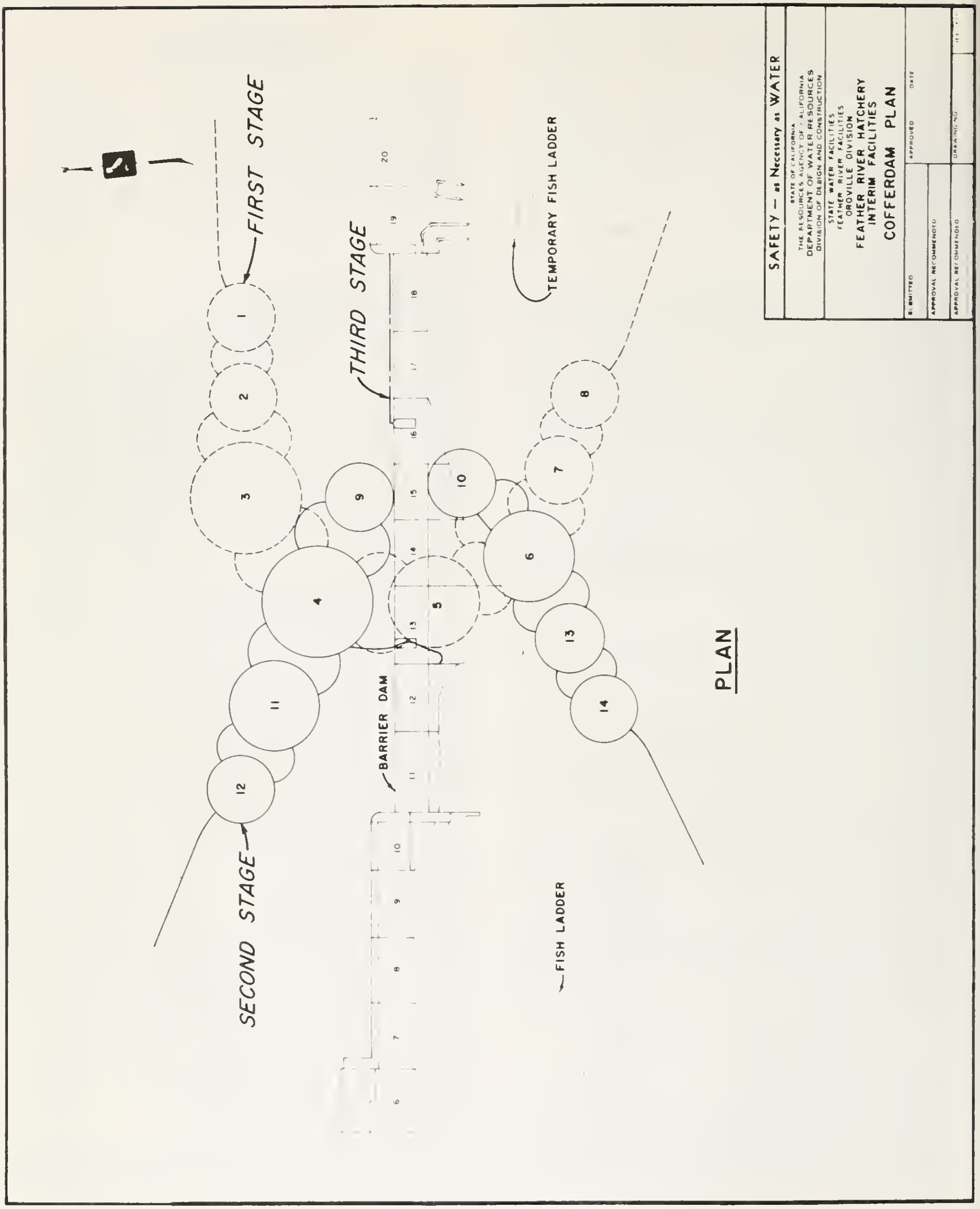


Figure 76. Layout of Cofferdam Cells

Figure 77. Closure of Cell 4

Figure 78. Failure of Cell 4

cells 1 and 2 were lost completely, and cells 3, 4, and 5 sustained severe damage. Cell fill was washed out because the cells were not concrete-capped. Because the sheets were not trimmed, they were damaged by the impact of floating debris and were twisted by the current (Figures 79 and 80).

Reconstruction of the first-stage cofferdam was completed January 10, 1963, including trimming and capping (Figure 81). On January 31, the River again topped the cofferdam. It peaked at a flow of approximately 191,000 cfs. Although this flow exceeded the October flood by about 50,000 cfs, damage to the cofferdam was considerably less. Cells 1 and 2 and the approach ramp were destroyed, but the remainder of the cofferdam was not damaged (Figure 82).

High flows on March 28 and April 8, 1963 topped the cofferdam again and washed out the cofferdam access ramps. After the latter flood, the contractor waited until April 22, 1963 before resuming work on the cofferdam. Subsequent to April 22, flows no longer interfered with progress, and the rebuilding was completed in May 1963. This time, cell 1 was not rebuilt but was replaced by an earthen dike between cell 2 and the abutment. The piling cutoff wall in the dike was not interlocked with the sheets of cell 2.

The primary problem encountered during construction of stage 2 was the occurrence of excessive leakage under cells 11 and 12 and around the end of cell 12. Tremie concrete was placed along the inside face of cell 12 but was not wholly successful in stopping the leakage. Also, a single row of piling was placed between cell 6 and the right abutment. The area between the piling and cells 13 and 14 was covered with a tremie concrete cap about 5 feet thick to stabilize the gravels at the base of cells 13 and 14 and reduce leakage. In addition to these measures, it was necessary to pump water continually from within the cofferdam during the placement of concrete.

Foundation and Monoliths

Excavation. Dam foundation excavation was started on the right abutment in the area above the normal water surface in March 1962. A dozer first removed a few feet of alluvial material overlying the bedrock, and then the rock was drilled for blasting. After shooting, the rock was excavated by a crane with a clamshell bucket. Excavated material was wasted in the area upstream from the right abutment. Excavation of the left abutment (Monoliths 19 and 20, Figure 76) was similar to that of the right abutment, except that there was little or no alluvial material to be removed prior to drilling and shooting of the rock.

In the streambed section (Monoliths 11 through 18), it was necessary to remove river gravels varying in depth from 5 to 25 feet to expose foundation rock. In Monoliths 10, 11, 17, and 18, weathered and fractured rock had to be blasted to achieve suitable foundation but, for the remainder of the monoliths, competent rock was encountered immediately below the gravels. A small amount of shooting was done in Monolith 12 to remove irregularities and to provide a more favorable foundation plane.

After all loose and fractured material that could be picked up by the clamshell was removed from the foundation area, final cleanup was done with an air-water jet and hand tools. All weathered seams were excavated to a depth at least equal to their top width. Surfaces were sandblasted prior to placement of concrete in cases where the rock was competent but had a film, a layer of mud, or other material that could prevent good bond.

Construction Chronology. Construction of the Fish Barrier Dam was accomplished in four phases: (1) Monoliths 1 through 9, for which no cofferdam was needed, were the first to be constructed, and work proceeded on them simultaneously with construction of the first-stage cofferdam; (2) monoliths were constructed inside the first-stage cofferdam with the exception of the top 5½-foot lift in each of Monoliths 17 and 18; (3) Monoliths 10 through 14 were constructed inside of the second-stage cofferdam; and (4) crest sections of Monoliths 17 and 18 were placed under protection of the third-stage cofferdam.

Construction Details. The only complication encountered in construction of Monoliths 10, 11, and 12 was a sharp downstream dropoff at the east end of Monolith 12. This was actually a continuation of a steep bluff at the joint between Monoliths 12 and 13. Because this surface plunged so deep into the river channel, it was not possible to dewater and expose the entire foundation of Monolith 12 without first starting the excavation for Monolith 13. Because it was advantageous to complete Monolith 12 before starting the excavation for Monolith 13, a soffit form was constructed to cut off the toe of Monolith 12 for an approximate width of 10 feet (Figure 83). The width was later added to Monolith 13.

Due to the depth of excavation required for Monoliths 13 and 14, it was necessary to place a blanket of tremie concrete over the foundation area. After the tremie concrete was placed, a drilling and grouting program was initiated to consolidate streambed materials below the tremie concrete and to establish grout curtains upstream and downstream of the foundation area so future excavations could be carried out with less leakage and risk of blowout under the cofferdam cells.

Meanwhile, a revised foundation plan for Monoliths 13 and 14 was conceived. As approved, this plan called for (1) excavating a 15-foot-wide slot through the tremie concrete (Figure 84) and underlying grouted gravels to competent bedrock for each of the two monoliths, (2) backfilling slots with concrete to form

Figure 79. Damage to First-Stage Cofferdam—October 1962

Figure 80. Damage to First-Stage Cofferdam—October 1962

Figure 81. Reconstruction of First-Stage Cofferdam

Figure 82. Damage to First-Stage Cofferdam—January 1963

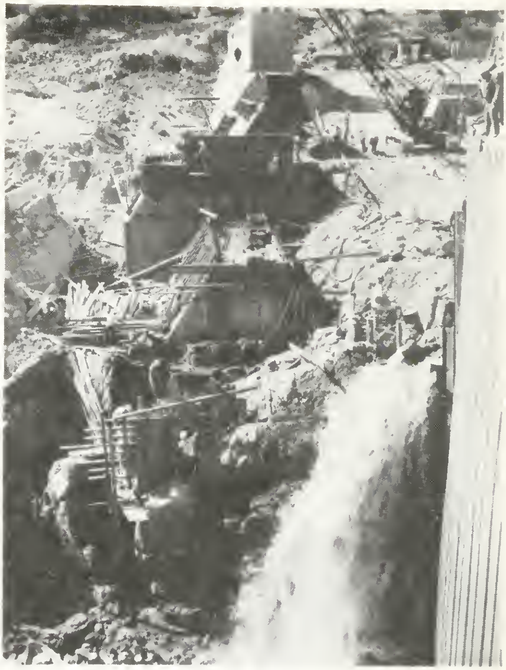


Figure 83. Soffit Form at Monolith 12

Figure 84. Excavation Through Tremie Concrete—Monolith 12

footings for the monoliths, (3) excavating 10-foot-wide cutoff walls between the footings, and (4) backfilling cutoff wall excavations with concrete. Figure 85 shows the dimensions of the footings and cutoff walls.

A core drilling program that was performed subsequent to placement of the tremie concrete blanket indicated that the bedrock surface in the footing for Monolith 13 varied from an elevation of 83 feet to 87 feet and for Monolith 14 from an elevation of 90 feet to 97 feet. The surface of the tremie concrete was placed at an average elevation of 108 feet. The required depth of excavation for the footings varied from about 11 feet to 25 feet. During and after performance of the excavations, it was necessary to shore the walls with steel sheet piling supported by a heavy steel frame (Figure 86).

When the foundation slots were backfilled to the top of the tremie blanket (elevation 108 feet), conventional construction methods were resumed, except that for the first two 5-foot lifts above this elevation, upstream faces of the monoliths were not formed and concrete was placed against the sheets of the cofferdam.

Mass concrete placed in the Fish Barrier Dam had 4-inch maximum size aggregate and contained pozzolan, an air-entraining agent and a water-reducing retarder. A great majority of the mass concrete had a cement content of three sacks per cubic yard, including 70 pounds of pozzolan. In a few instances, a five-sack mix was utilized, such as in some of the crest sections where the new concrete could have been subjected to early flooding or where early stripping of forms was desirable. Tremie concrete placed in the foundations for Monoliths 13 and 14 contained six sacks of cement (including 70 pounds of pozzolan) and had 1½-inch maximum size aggregate. Normal mass concrete was placed at 1- to 2-inch slump, and slump of the tremie concrete was maintained at 7 to 8 inches.

Fish Barrier Dam concrete was placed in 5-foot lifts. Steel forms, supported by cantilevers bearing against the lift below, were used for all lifts except the leveling courses placed on the foundation. Cantilever supports were supplemented by rods welded to pins embedded in the previous lift. These were essential during the construction of Monoliths 13 and 14 where time was of the essence due to flood danger, and placements were made on each monolith on alternate days, giving only 48 hours between lifts. Figure 87 shows typical placement operations.

Concrete Production

The batching plant was a semiautomatic plant with a weigh hopper capacity of 2 cubic yards and a maximum batching capacity of 80 cubic yards per hour. A separate silo and scales were used to store and weigh the pozzolan, which was discharged into the mixer charging belt directly behind the batch plant weigh hopper gate.

Grouting Under Contract. A total of 31 cubic feet of cement was used in the grouting done under contract. The 12 holes that were drilled and grouted in the foundation area of Monoliths 17 through 20 and Monolith 8 were located to intersect joints in the foundation rock which possibly could have transmitted water.

Grouting Under Force Account. Major grouting work was done under force account in connection with the foundation treatment for Monoliths 13 and 14. The program consisted of drilling and grouting to establish grout curtains along the upstream and downstream limits of the Monoliths 13 and 14 foundation areas.

In general, the holes were drilled, washed, and grouted in a three-stage program. The first stage penetrated the tremie concrete to the interface between tremie and streambed material, the second extended 5 feet below the tremie, and the third extended into bedrock.

A total of 69 holes were drilled and grouted, 12 of which were diamond-drill holes. Diamond-drill holes were drilled at the end of the program to verify the effectiveness of the grouting. It was found to be satisfactory.

Clearing and Grubbing

Clearing and grubbing commenced on March 5, 1962 and essentially were complete by the end of March. In addition to reservoir clearing, 6 acres of land upstream from the original clearing limits on the west side of the River were cleared and grubbed under a contract change order. A minor amount of clearing of regrowth was done in 1963 and 1964.

Interim Fish Ladder and Appurtenances

Fish Ladder. Construction of the interim fish ladder was divided into two parts. The upper reach, which was not normally subject to inundation and which required no cofferdam, was constructed in the fall of 1962. The lower reach was constructed in October and November 1963, after the second-stage cofferdam was installed.

Mechanical Equipment. Major items of mechanical equipment appurtenant to the interim gathering facilities were the fish sweep and the fish conveyor which were installed in July 1963.

Figures 88 and 89 show the sweep and conveyor in operation. The conveyor subsequently was removed when the permanent hatchery was constructed while the sweep was modified and incorporated into the new gathering pond adjacent to the spawning building.

Conduits. Reinforced concrete pipe for the gravity flow conduits supplied attraction water to the fish ladder.

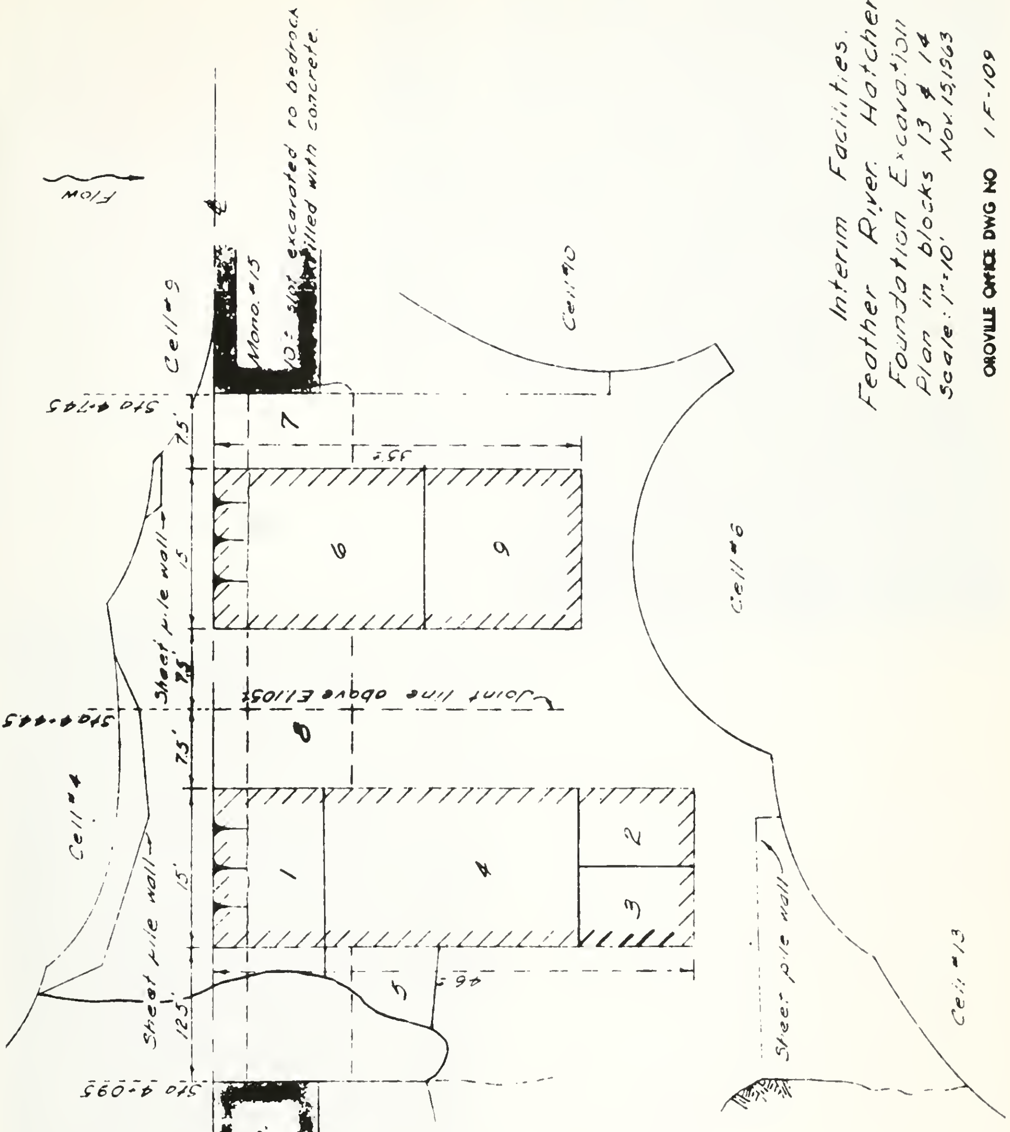


Figure 85. Foundotion Excavation—Monoliths 13 ond 14

Figure 86. Piling Support Frame—Monolith 13

Figure 87. Typical Concrete Placement in Monolith

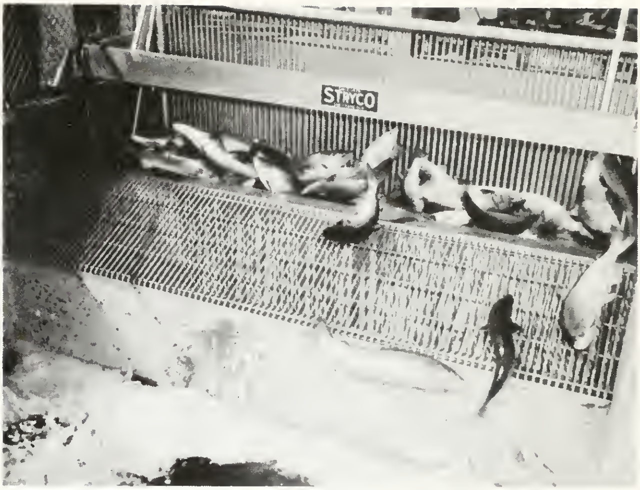


Figure 88. Fish Lifted From Gathering Tank to Dope Tank by Fish Sweep

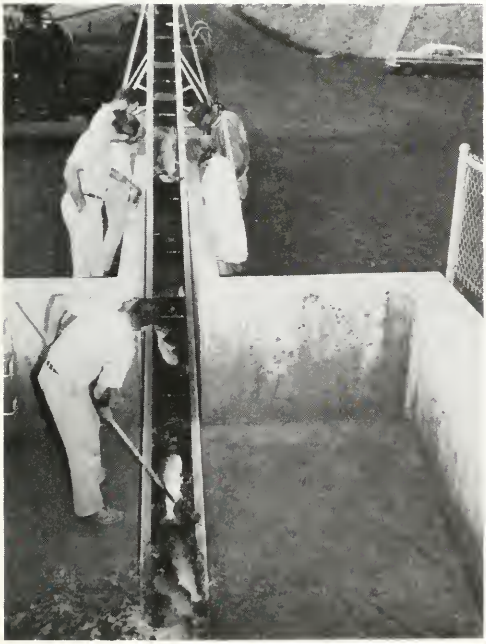


Figure 89. Fish Riding Conveyor From Dope Tank to Truck

A 24-inch pipe was installed and tested satisfactorily in January 1963, and a 21-inch pipe was installed in October and November 1963. A 16-inch-diameter steel pipe for the interim gathering tank supply line was installed in July 1963.

Sluice Gates and Pumps. The 21- and 24-inch water supply conduits are gated with circular sluice gates located in the pumping plant structure. These gates were manually operated by weatherproofed floor stands.

Two vertical-shaft, mixed-flow pumps supplied water to the interim supply line.

Construction of the Feather River Fish Hatchery

Contract Administration

The Feather River Fish Hatchery, its appurtenances, and the fish ladder were constructed under one contract designated Specification No. 66-18. General information for this contract is shown in Table 3. The completed hatchery is shown on Figure 90.

TABLE 3

Major Contract

Feather River Fish Hatchery

Specification	66-18
Low Bid Amount	$3,209,462
Final Contract Cost	$3,394,700
Total Cost-Change Orders	$108,985
Starting Date	5/16/66
Completion Date	12/12/67
Prime Contractor	Peterson and Brown-Ely

Site Grading

Required grading consisted of cutting back into low-lying hills and using the excavated material to fill low areas or wasting it in spoil areas. Most of the excavation was done by three scrapers. A crawler tractor with ripper teeth was used in areas where the material was too hard for scrapers but soft enough to be ripped without blasting. Some blasting was necessary, mostly in the area of the office-maintenance building.

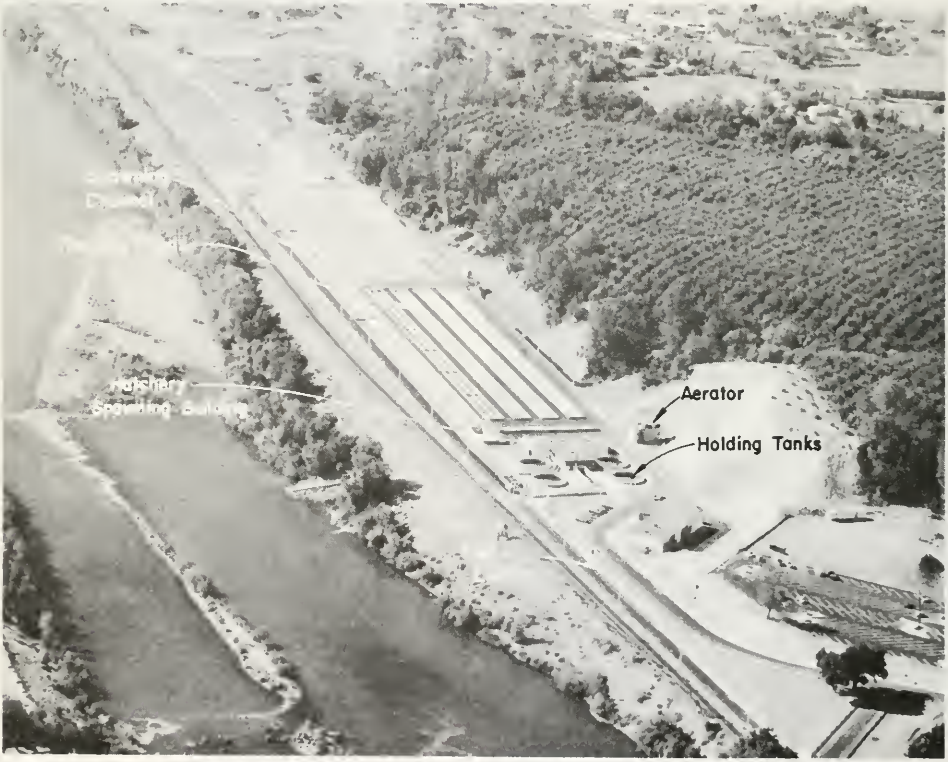


Figure 90. Completed Hatchery

About 10,000 cubic yards of rock were removed and stored for use as grouted rock-slope protection. Practically all site excavation was done during the dry summer months. The total quantity of material excavated was 142,000 cubic yards.

Buildings

Hatchery-Spawning Building (Figure 71). This is a T-shaped building, the smaller part, 44 feet - 8 inches by 30 feet - 0 inches, being the spawning room. It was constructed with concrete foundation walls under split-face block and porcelain and glass panels. The floor is concrete and the ceiling is metal lath and plaster.

The hatchery room is of "tilt-up" concrete construction, and its size is 44 feet - 1 inch by 98 feet - 1 inch. The walls are 8 inches thick. Hollow core-block partitions form a cooler room, toilet, and mechanical and electrical room. The floor is concrete and the ceiling is metal deck.

The roof is built-up composition with gravel over metal deck and insulation.

Operations and Maintenance Building. The operations and maintenance building is 113 feet - 10 inches by 47 feet - 1 inch in size. Floors are concrete, and walls are 8-inch, "tilt-up", concrete panels or porcelain enamel and glass. The roof is insulated, built-up composition on a metal deck supported by steel beams on concrete columns. Floors in the toilets and shower are finished with polyester terrazzo and those in the training room and office with vinyl asbestos tile. Interior walls are hollow core-block or plaster on metal studs and lath. Ceilings are metal deck material in the shop and warehouse areas and in more refined areas are suspended plaster and suspended plaster with glued-on acoustical tile.

Miscellaneous Concrete Structures

The fish ladder, gathering tank, holding tanks, spawning channel, rearing ponds, and aerator were constructed by standard methods. Floor slabs were placed and allowed to set; then walls were formed with plywood panels. Approximately 8,400 cubic yards of concrete was placed in these structures. Completed structures are shown on Figures 91, 92, 93, and 94.

Concrete Production

Concrete was dry-batched at a commercial batch plant in Oroville in 2-cubic-yard batches and hauled to the job site in compartmented dump trucks capable of hauling 4 to 6 cubic yards. Dry ingredients were mixed with water and a water-reducing agent by a 2-cubic-yard portable mixer. Ice was crushed at the mixer and used when required to keep the concrete temperature at or below 70 degrees Fahrenheit. Concrete was transported in 1-cubic-yard buckets on flatbed trucks and placed using a 25-ton truck crane.

Raw Water Line

The raw water line begins at Thermalito Diversion Dam and ends at the hatchery aerator, a distance of approximately 5,100 feet. Approximately 4,650 feet of 54-inch reinforced concrete pipe and about 50 feet of 58-inch welded steel pipe were placed in addition to 400 feet of 60-inch pipe already in place near the Diversion Dam.

Project Accomplishments

The Feather River Fish Barrier Dam and Hatchery provide a complete complex incorporating the essential features necessary for trapping, holding, and spawning approximately 9,000 King salmon and 1,000 adult steelhead trout that annually migrate upstream into the Oroville area. About 20,000,000 eggs are taken annually, and the subsequently hatched offspring are raised to varying stages of maturity before being released into the River to begin their journey to the Pacific Ocean.

A total of 81,000 people visited the Feather River Fish Hatchery during the 1973–74 fiscal year. Among this number were various groups which were given tours of the hatchery facilities by the Department of Fish and Game and the Department of Water Resources.

Figure 91. Barrier Dam and Overlook

Figure 92. Fish Ladder

Figure 94. View of Rearing Ponds from Aerator

Figure 93. Gathering Tank and Fish Sweep

Figure 95. Delta Fish Protective Facility

CHAPTER VII. DELTA FISH PROTECTIVE FACILITY

General

The Delta Fish Protective Facility is located approximately 3½ miles east of the City of Byron and immediately north of Byron Road. It is adjacent to Clifton Court Forebay and is serviced by the left and right operating roads of the California Aqueduct intake channel (Figures 95 and 96).

The purpose of the Delta Fish Protective Facility is to prevent damage to the fish population of the Sacramento-San Joaquin Delta which might result from the attraction of fish into the California Aqueduct by a large water diversion. To fulfill this purpose, two basic functions are necessary. First, the fish must be collected from the water passing into the California Aqueduct. Second, the fish then must be delivered back to Delta waters at such locations as to avoid their return to the intake channel of the Delta Pumping Plant. The Facility was designed to be capable of salvaging a reasonable proportion of four main species of fish: King Salmon, Striped Bass, White Catfish, and Threadfin Shad of at least 1 inch in length. It is not feasible to successfully collect eggs or fish of the larvae stage at the Facility.

Chronology

Investigations to determine the location and type of facility were initiated in January 1962. Coordination with other state and federal agencies and studies of fish removal, collection, and transportation systems resulted in the selection of a louver type of facility. Model studies, preliminary design, and site exploration were pursued until July 1964.

Final design and preparation of the plans and specifications were started in July 1964 and were completed in the spring of 1966. Construction of the project was undertaken in May 1966 and the last contract completed by January 1970.

Geology

The Delta Fish Protective Facility is located at the southwestern edge of the Sacramento-San Joaquin Delta, where the flat delta basins merge with the foothills of the Coast Range. The Facility lies on a heterogeneous mixture of alluvial deposits washed down from the foothills of the Coast Range and sediments washed out from the edge of the Sacramento-San Joaquin Delta.

No known active faults exist at the Facility. The lateral acceleration due to earthquake was assumed to be 0.1g for design purposes.

Design

Description

The Facility is a large complex structure consisting of primary and secondary systems (Figure 97). The primary system is comprised of a floating trash boom, inlet transition, trash conveyor, trashrack and roadway structure, flow control gates, an open channel, louver area, gantry crane, bypass inlets, pipes connecting these inlets to a valve chamber, and an outlet transition. The secondary system consists of the valve chamber, inlet transition, louver area, an open channel, pumping plant, discharge conduit, valve gallery, bypass inlet, traveling water screen, and four holding tanks.

The function of the primary system is to remove fish from the water going to the Delta Pumping Plant and, in so doing, concentrate the fish into about $\frac{1}{30}$ of the volume of flow. The secondary system further concentrates the fish into about $\frac{1}{15}$ of the volume of flow and finally collects up to several thousand fish in 500 gallons of water.

The primary channel is 383 feet long, 158 feet wide, and 29 feet deep. A trash boom diagonally crossing the channel is anchored on the right bank. Floating debris is deflected to the left bank where it is deposited on a partially submerged belt conveyor that elevates it to a trash loading pit.

Downstream of the trash conveyor, the channel converges into a rectangular, reinforced-concrete, channel section. At the start of the rectangular section, the channel is divided into seven bays by piers supporting a trashrack and bridge. The bridge serves as a roadway and access for operation of the trashrack rake. Following the roadway, pairs of vertical wing gates in each bay control flow through the channel.

Downstream of the control gates section, the channel is divided into five bays, three of them containing single rows of louvers and two containing two rows of louvers in a vee pattern. The louvers, on an angle of 15 degrees with the walls, direct the fish into primary bypass inlets, while the main body of water flows through the louvers and continues to Delta Pumping Plant.

Two bypass pipes connect the primary bypass inlets "A" and "B" of the four presently operating channels to a valve chamber. Two additional pipes, "C" and "D", will serve the three stoplogged channels upon expansion of the Facility.

From the valve chamber, fish enter the secondary channel louver area (Figure 98) in water having a high concentration of suspended debris (mostly peat). The louvers direct the fish toward the secondary channel bypass inlet where valved pipes extend to four holding tanks.

To reduce the amount of debris reaching the holding tanks and thus prevent clogging of the holding tank outlet screens, a small percentage of the second-

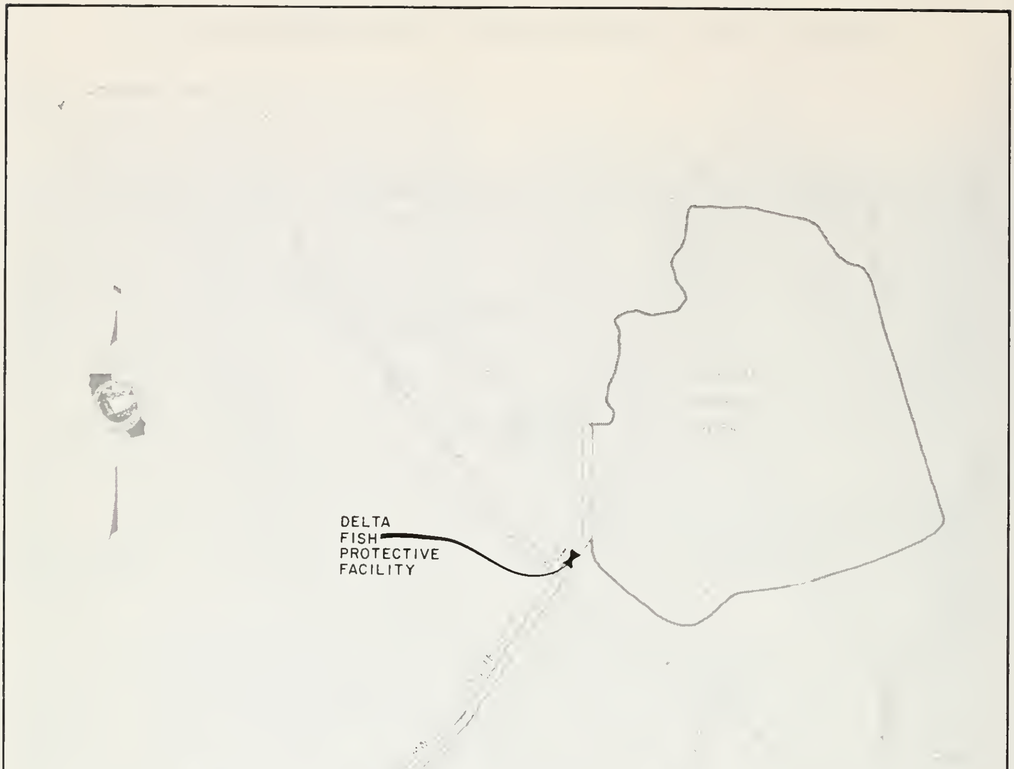


Figure 96. Location Map—Delta Fish Protective Facility

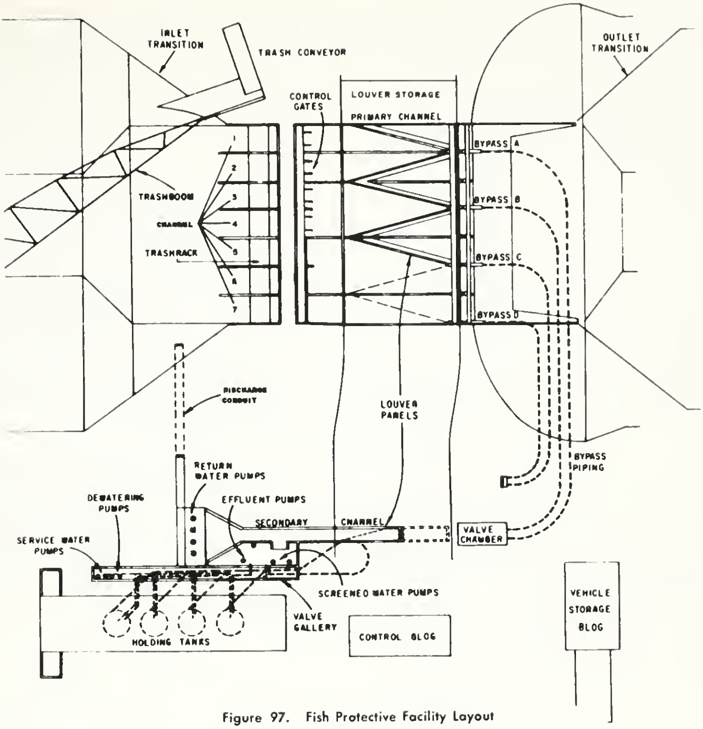


Figure 97. Fish Protective Facility Layout

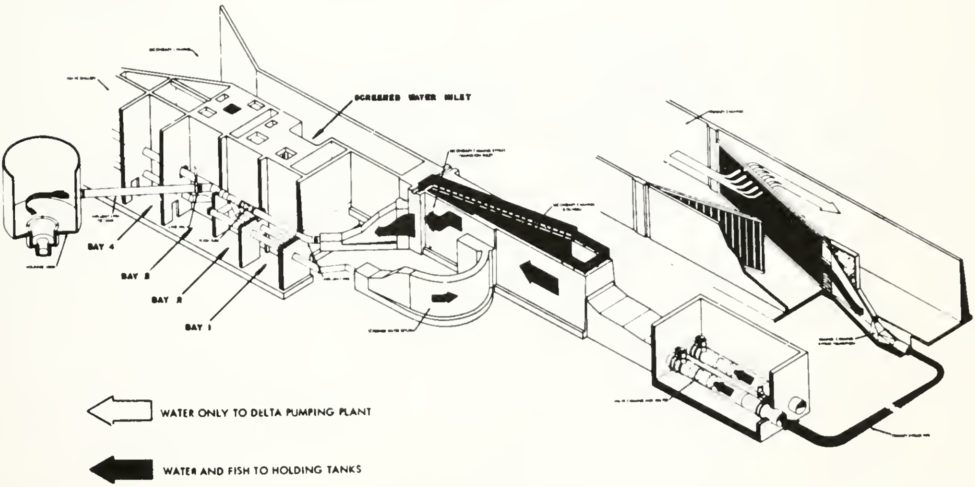


Figure 98. Fish Collecting Features

ary channel flow, after passing through the secondary louvers, is diverted to a screened water inlet. There, a traveling water screen removes most of the peat and other suspended debris. The screened water then is pumped into the secondary channel just upstream of the secondary channel bypass inlet. By running this screened water along the wall of the secondary channel, fish pass into the bypass inlet in water relatively free of screen-clogging debris.

From the secondary bypass inlet, an influent piping system carries the fish to one of the holding tanks. There the water passes through fine cylindrical screens leaving the fish behind to be collected and transported to discharge sites on the Sacramento River near Antioch.

Water passing through the secondary louvers and water drained through the holding tanks is pumped back to the primary channel through a discharge conduit. The pumped water enters the inlet transition of the primary channel at the right transition wall.

Primary System

Trash Boom and Trash Conveyor. The trash boom, a 388-foot-long, floating, steel truss serving as a trash deflector, is located across the inlet transition of the primary channel (Figure 99). It was designed to deflect debris at all water-surface elevations in an 11-foot range and is skewed 37 degrees to the direction of flow. Debris consists of floating and partially submerged objects, such as logs, tree branches, and boards, and smaller items such as bottles and cans.

In designing the trash boom, it was necessary to assume that its dead weight and the buoyant forces of the channel water provide stability so that the structure acts as a truss. Reaction arms were designed to transmit the end reactions of the truss into the concrete wall structures. All members of the truss are pin-connected.

The upstream chords were designed as pontoons to provide enough buoyant force to support a deflector plate, a walkway extending the full length of the trash boom, and one-half the dead weight of the web struts. Pontoons at each end of the truss were enlarged to carry the dead weight of the reaction arms. Diagonal braces, which are hollow, are oriented parallel to the flow and provide buoyance for the downstream chords and one-half the dead weight of the web struts.

No overstress was allowed in the design of the truss. One-third overstress was allowed in the design of the reaction arms because they are independent of the assumption that buoyance and dead weight will make the trash boom act as a truss.

The trash conveyor consists of a structural steel frame of welded and bolted construction. The conveyor is supported by a swivel that allows it to be rotated upward into a horizontal position for maintenance and repairs.

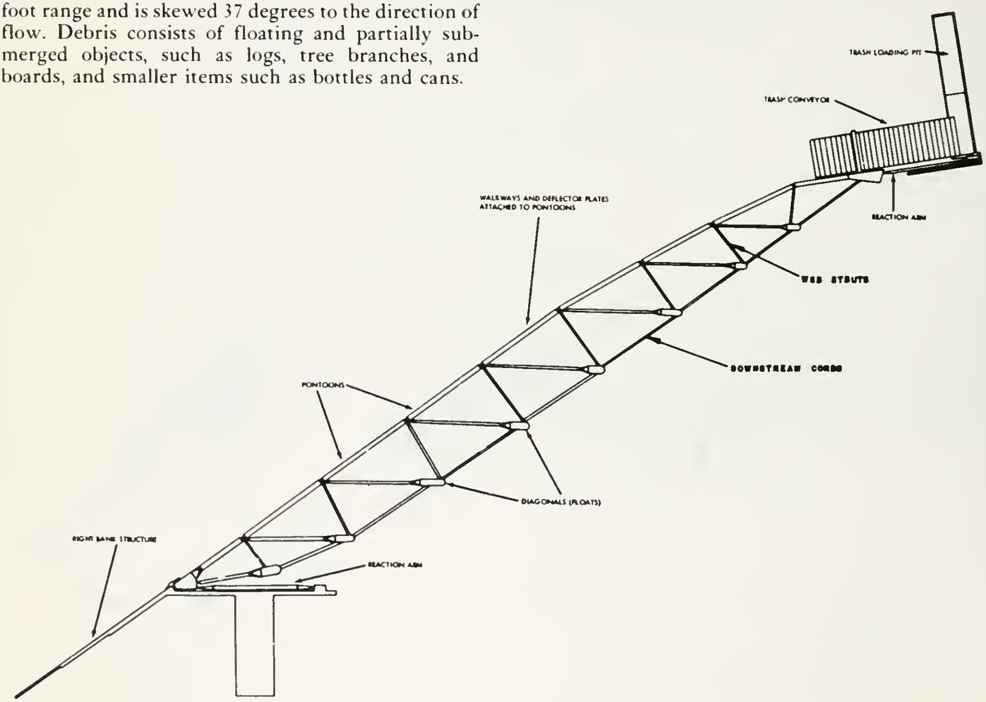


Figure 99. Trash Boom Layout

Trash Boom Right Bank Structure. The trash boom right bank structure consists of a reinforced concrete wall and an access roadway supported on piles. This structure serves primarily as anchorage for the upstream end of the trash boom. The roadway provides access for heavy equipment for maintenance of the trash boom.

Inlet Transition. The inlet transition is largely a reinforced concrete-lined structure (Figure 100). This structure forms the transition between the cross-sectional configuration of the California Aqueduct intake channel and that of the Fish Protective Facility primary channel. Reinforced concrete transition walls are laid on ground slopes that vary from 2:1 to 1½:1. The remaining lined portion of the transition is reinforced concrete counterfort walls conforming to the varying slope from 1½:1 to vertical.

The discharge conduit from the secondary channel pumping plant daylights through the right transition wall of the inlet transition. In this region, the supporting counterforts of the transition wall serve as sidewalls of the conduit. The discharge conduit terminates flush with the transition wall slab. The inlet left transition wall contains the trash conveyor pit entrance.

Trash Conveyor Pit. The trash conveyor is located on a concrete structure in the left side of the inlet transition at a slope of 3:1, with the lower end always underwater. The pit forms retaining walls and anchor points for the conveyor and the trash boom left side reaction arm.

Trash Loading Pit. A loading pit provides access for trucks to the upper end of the trash conveyor. This pit is 12 feet wide to permit a 10-cubic-yard dump truck to be backed under the conveyor to receive the debris collected by the trash boom. The approach ramp has a 12½% slope with 4-foot-high sidewalls.

Primary Channel. The primary channel (Figures 101 and 102) rectangular section is 158 feet wide (between centerlines of abutment walls). It was designed to pass the 10,300-cubic-foot-per-second (cfs) maximum capacity of Delta Pumping Plant plus a tidal flow of about 700 cfs. Also, it was designed for a wide variation in the quantity of flow. Initially, the variation was caused mainly by tidal fluctuations. Now the daily and weekly off-peak pumping pattern from Clifton Court Forebay is the main source of fluctuation. For efficient fish guidance, it is necessary to keep velocity of flow through the primary channel between 1½ feet per second (fps) and 3½ fps. To fall between these maximum and minimum velocity requirements with various incoming flows, the primary channel is divided into small channels by interior walls. Flow through these individual channels is regulated by flow control gates.

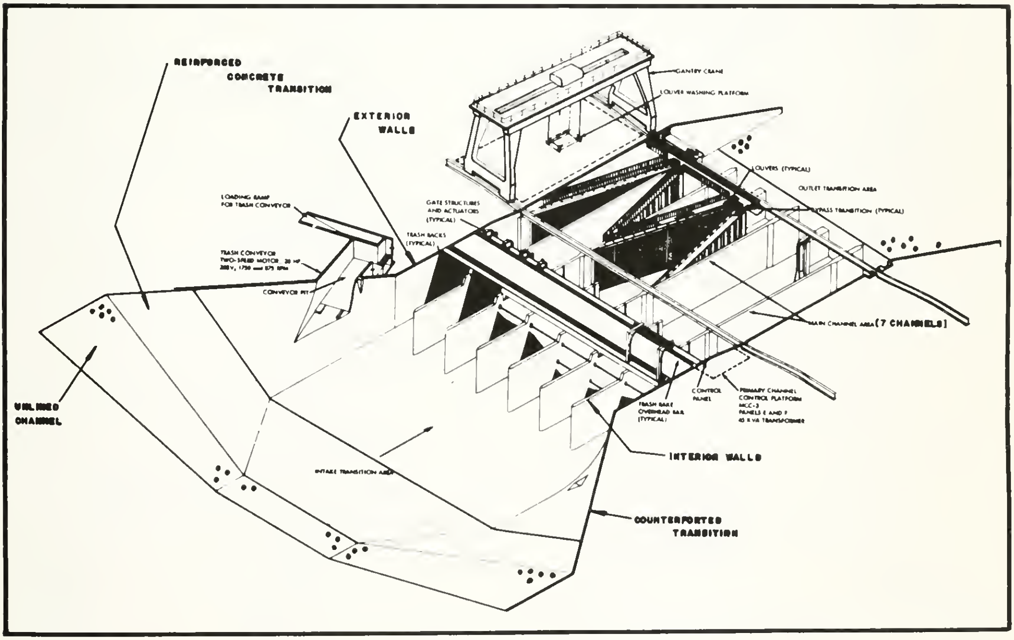


Figure 100. Primary Channel Layout

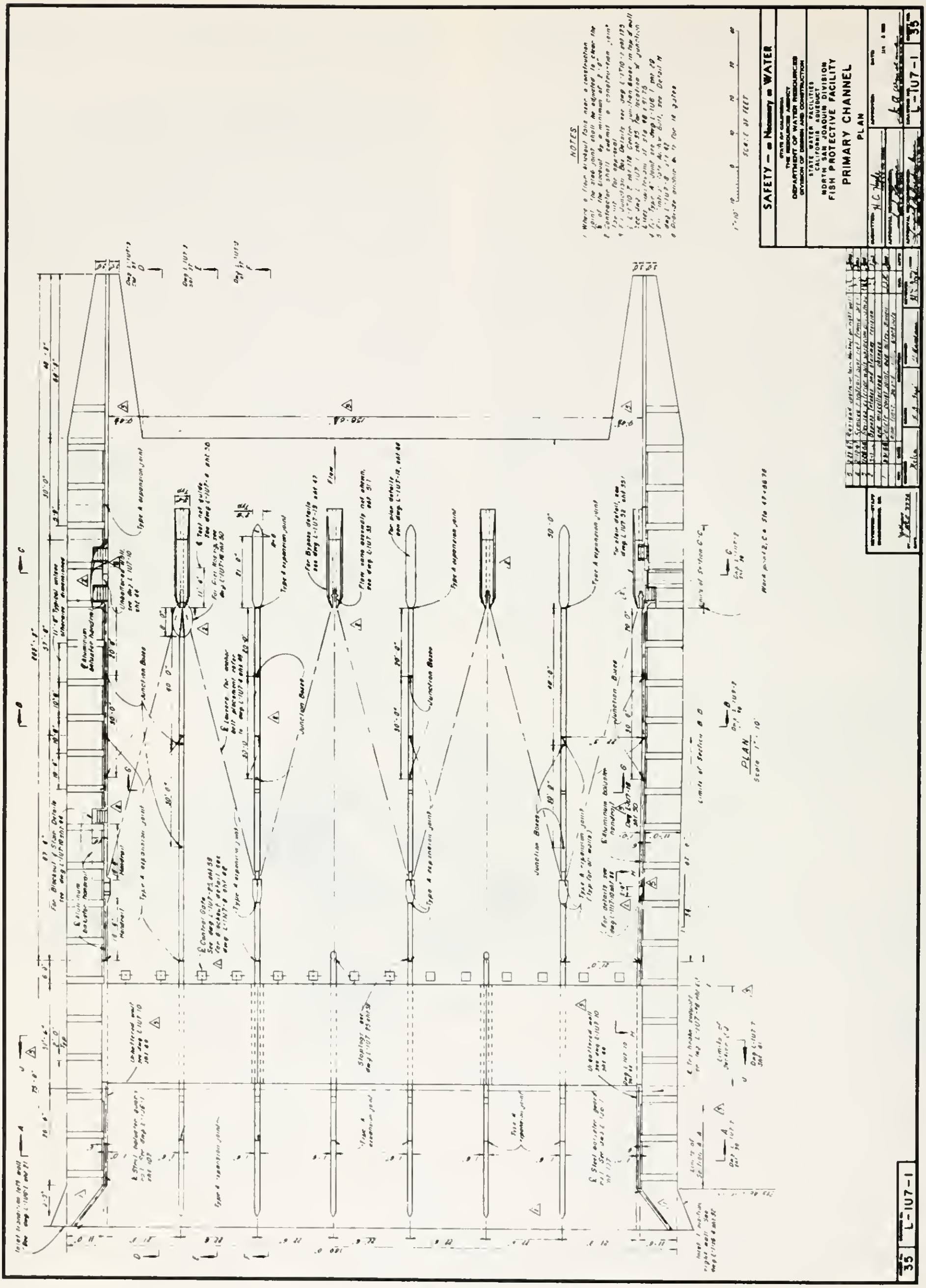


Figure 101. Plan of Primary Channel

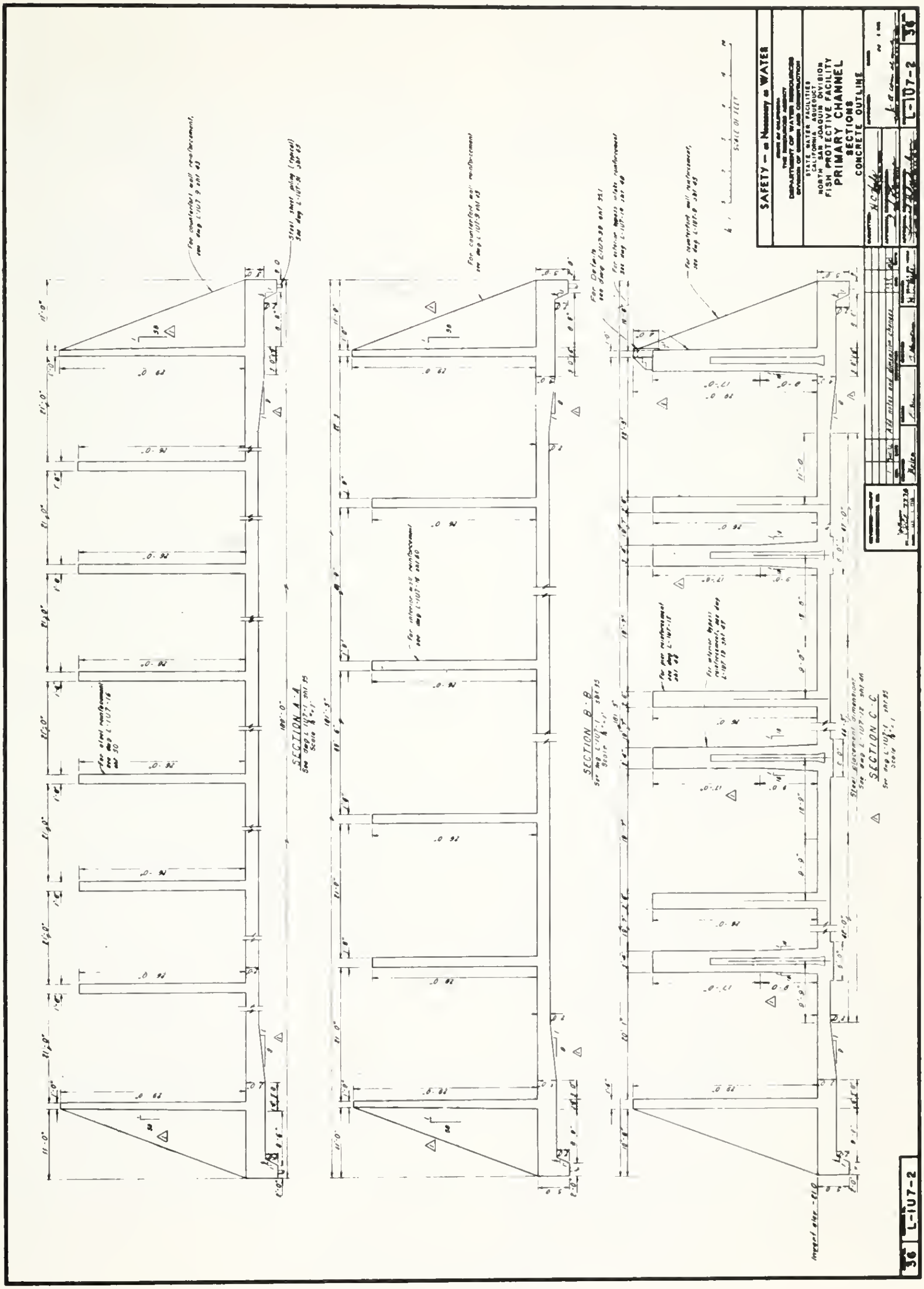


Figure 102. Primary Channel Sections

Primary Channel Hydraulics. In designing the primary channel, model studies determined that 25 feet between control gates and louvers would yield an acceptable velocity distribution immediately upstream from the louvers. An acceptable velocity distribution exhibits smooth flow conditions which enable the fish to readily sense the turbulence caused by the louvers. Apparently, once the fish sense their downstream movement is blocked, they swim away from the turbulence and are directed into the primary bypass inlet (Figure 103).

At the upstream end, interior walls are spaced uniformly on 22½-foot centers between the abutment walls to divide the primary channel into seven channels. Three channels on the right side are stoplogged pending expansion to a 10,300-cfs facility. Interior walls support the roadway structure.

Roadway Bridge Structure. The reinforced concrete roadway structure spans the primary channel on piers just downstream from the inlet transition and upstream of the flow control gates. It supports the stoplogs and control gates plus their asssociated mechanical equipment, trashracks, and trashrake, and provides the means for operations and maintenance vehicles to cross the channel.

To calculate the moments and shear values, the exterior wall and interior wall bases were considered fixed to the primary channel floor with the tops pinned at the roadway deck. A computer program for multimember structure analysis was used to determine final moment and shear envelope ordinates.

Trashracks. Trashracks with 2-inch vertical openings are located on the upstream side of the roadway structure and prevent the passage of floating and submerged debris into the primary channel which may be swept under the floating trash boom. Trashrack panels are about 3 feet wide and 35 feet long, with the bars inclined on a ½:1 slope.

Trashracks are cleaned when they become sufficiently clogged by debris to create a head loss of 6 inches. A mechanical rake, which is lowered and raised on the trashracks, cleans the racks and then continues up a stainless-steel apron to dump into a truck (Figure 104). This rake is operated by a 2-ton hoist which travels along an I-beam monorail. The apron is attached to a motor-operated cart that travels on rails installed in the roadway deck adjacent to the trashracks.

Trashrack bars were designed for a total design load of 6,250 pounds parallel to the bars as the hoist raises the trash-laden rake. This loading is transferred to the columns as bending moments, torsional moments, and axial loads. Required beam and column sections and final geometry were chosen to carry this loading.

Flow Control Gates. A system of flow control gates was designed to regulate velocity of the water through the primary channel. These wing-type gates were fabricated from heavy 12-inch pipe for the center posts with ¼-inch steel plate bodies braced with structural members and vertical 3-inch-diameter steel pipe at the sides. They are 25 feet-8½ inches high and 10 feet-2 inches wide with a thickness tapering from the 12-inch double heavy pipe in the center to the 3-inch standard weight pipes at the sides. Gate guide posts were installed in all seven channels across the primary channel. Two gates were installed in each of the first four channels as needed to complete the first phase of the Delta Fish Protective Facility.

It is not necessary for gate closure to form a watertight barrier. Design assumed a maximum head differential of 2 feet across the closed gate. The resultant force of the water on the gates was determined by combining hydrostatic pressure with dynamic pressure.

Description of Walls. Walls of the primary channel are reinforced concrete and include exterior walls, interior walls, and outlet transition walls. The top of the exterior walls is 3 feet higher than the top of the interior walls. Expansion joints are provided upstream of the bridge roadway, at the connection to the control gate area, at the connection to the outlet transition, and approximately halfway between the gate control area and the outlet transition.

Design of Exterior Walls. Exterior walls are counterforted with panels designed as plates fixed on three edges. Since a key is provided at the heel, the heel slab was designed as being fixed on three edges and simply supported over the key (Figure 102). Then the key was designed as a beam to carry this reaction.

The stability of the exterior walls was analyzed by considering sliding and overturning forces. The component of sliding force toward the channel not resisted by friction was assumed to be taken by thrust from the floor slab. This slab was checked against buckling as an axially loaded member. Compaction of the pervious backfill behind the walls was not permitted, thereby reducing the horizontal design loading for the walls and preventing large differential pressures by allowing proper drainage of ground water.

Design of Interior Walls. Interior walls were designed as cantilevered retaining walls. The minimum width of footing for the interior walls was established by the allowable soil-bearing pressure. The actual width of floor slab reinforced as wall footing was determined by configuration and physical layout requirements.

Design of Outlet Transition Walls. The sloping outlet transition walls were designed with counterfort supports from the vertical primary channel walls to the section having a height of about 16 feet and as cantilever for the remaining length. Footing width was determined to achieve an allowable soil-bearing pressure for the loading conditions encountered. Walls were designed for a full-channel and an empty-channel condition using the same analysis employed for the exterior walls.

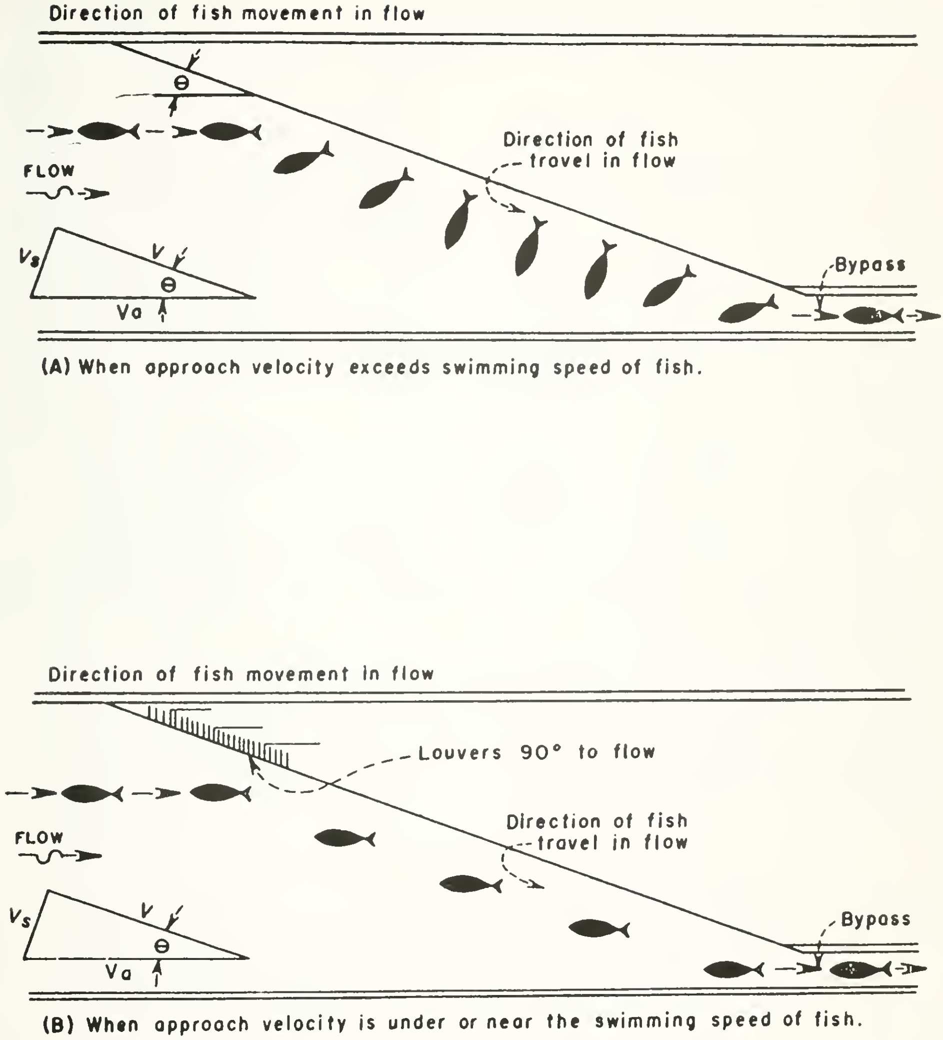


Figure 103. Reaction of Fish to Louvers

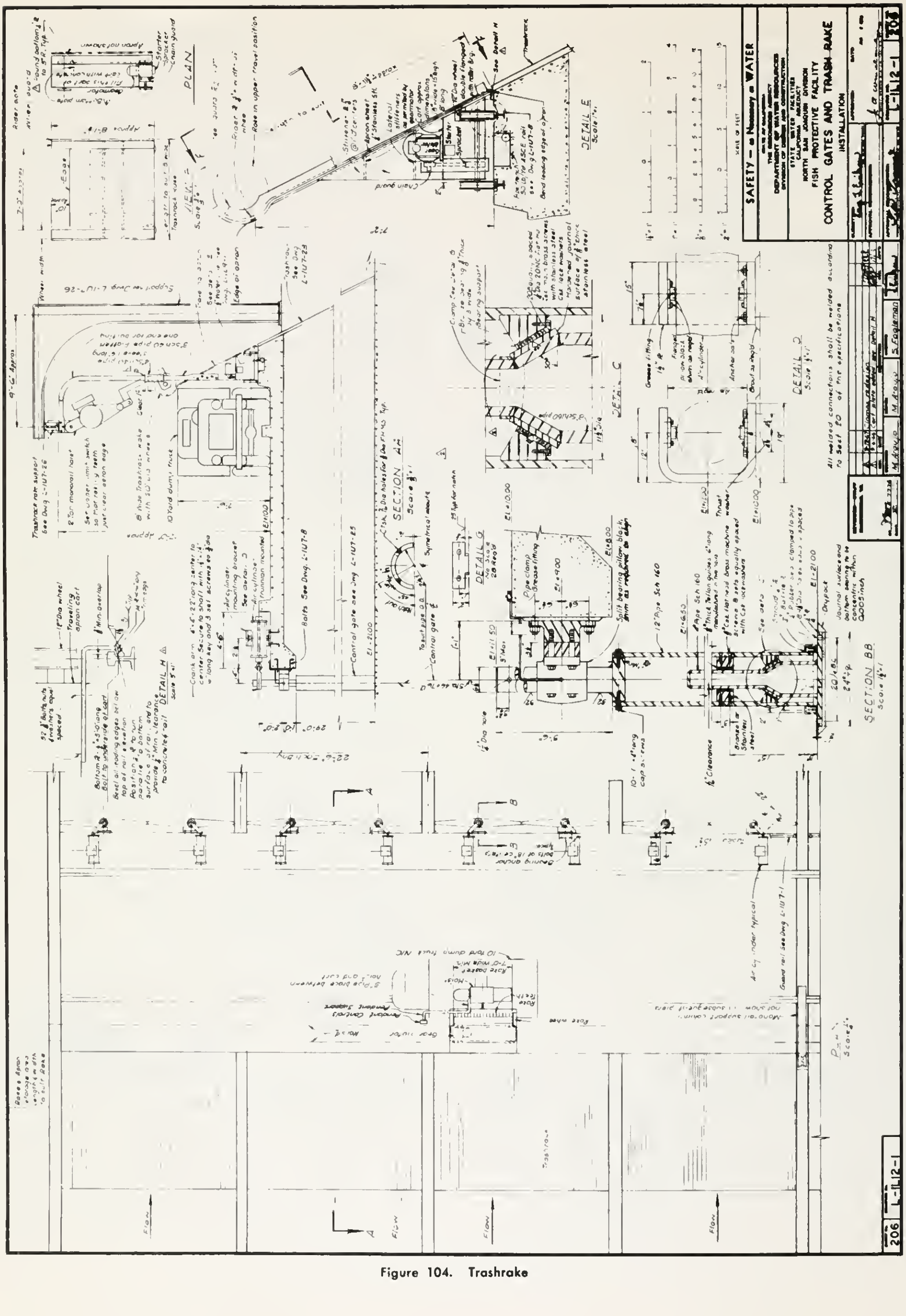


Figure 104. Trashrake

Foundation Analysis. The soil-bearing capacity under all primary channel wall footings was derived by a general soil-bearing-capacity equation. A factor of safety of 3 was set as minimum for the ratio of allowable-to-actual bearing pressure.

A flow net analysis indicated that seepage forces beneath the primary channel floor slab could become critical, so a steel sheet piling hydraulic cutoff wall was designed to envelop the primary channel foundation (Figure 101). It extends down to impervious strata from the bottom of the heel to reduce seepage to a volume which readily can be handled by a drain system under the primary channel structure.

Primary Bypass Transitions. The function of the primary bypass transitions is to act as a conversion between the rectangular conduits carrying the diverted fish and the bypass pipes (Figure 105). The configuration and dimensions of these structures were chosen to best satisfy the requirements of fish guiding efficiency. These hydraulic and guidance properties were determined by model studies. The structures were assumed to act as rigid frames and were designed to resist the full external hydrostatic head acting when the bypass is dewatered.

Flow vanes for achieving flow distribution were designed as inserts to be dropped into vertical slots located in the liners of the structures. They are removable for cleaning and inspection. These slots also can serve as stoplog slots.

Guides were also provided in the exterior walls of the structures about 11½ feet downstream from the bypass intakes to accommodate test nets (Figure 106). They were used to determine the fish diversion efficiency of the Facility in 1970 and 1971.

Bypass Pipes. The four bypass pipes consist of one 54-inch and three 48-inch, precast, reinforced concrete pipes. The primary bypass transitions discharge the water containing the diverted fish into the 54-inch and one 48-inch pipeline. The other two 48-inch pipelines are bulkheaded for use after ultimate phase expansion. The flow is redirected 180 degrees on its way to the secondary system.

Louver Storage Area. A storage area for the louvers, located adjacent to the left channel wall, consists of upright, aluminum, storage racks bolted to a concrete floor slab.

Gantry Crane. A 5-ton-capacity gantry crane (Figure 107) is used in the installation, removal, and cleaning of the louvers in both the primary and secondary channels. Reinforced concrete footings support the gantry crane rails on each side of the louver storage area. The gantry crane is supported by beams spanning the distance between the walls in the primary channel. These beams also serve as supports for three flowmeter platforms and a cable tray for the gantry crane power cable.

Secondary System

Valve Chamber. The valve chamber is a buried reinforced concrete box situated between the primary bypass pipes and the inlet transition to the secondary channel (Figure 108). The 54-inch pipe is reduced to a 48-inch pipe using a special reducer section just before it enters the valve chamber. The chamber houses a butterfly shutoff valve, velocity meter, and butterfly regulating valve for each of the two 48-inch pipes passing through it. A second valve chamber will be added during ultimate phase expansion.

Inlet Transition. The inlet transition is a buried reinforced concrete conduit forming the transition between the two 48-inch bypass pipes and the open flow secondary channel. It is situated just downstream from the valve chamber and in line with the valve chamber and secondary channel.

A 6-foot-long, 48-inch-inside-diameter, double-barreled, concrete, pipe structure joins the valve chamber of the secondary inlet transition. Expansion joints separate this structure from the valve chamber and the inlet transition.

Louver Area. The secondary channel louver area, located between the expansion joint at the end of the inlet transition and the expansion joint at the outlet transition, is a 10-foot-wide, 18-foot-deep, reinforced-concrete, rectangular, open channel. This channel section contains a row of louvers on an angle of 15 degrees with the walls to further concentrate the fish and reduce the amount of flow containing the fish. A bypass inlet at the lower end of the line of louvers directs the flow containing the fish to a pipe leading to four holding tanks.

Provisions were included for installing a system of testing nets for an efficiency evaluation program for the secondary system (Figure 106). During tests, nets are installed in two locations in the secondary channel to screen its total flow. The first location is immediately downstream from the inlet transition and in front of the louvers, and the second location is downstream from the louvers. A set of test net-frame assembly guides was designed and incorporated in the vertical walls of the channel at each of the above two locations. The additional channel length necessary for the net was included in the final length of the secondary channel louver area.

A screened water-outlet transition is located in the left wall of the channel just upstream from the bypass intake. Its purpose is to direct screened water along the left wall to the bypass intake, thereby enabling fish to flow into the bypass transition in cleaner water than otherwise would be possible.

The louver support pipes are embedded in the floor of the channel and are supported at the top by a concrete walkway running parallel to the line of louvers. Incorporated in this walkway slab is a reinforced concrete beam designed to support the wheel load of the gantry crane during removal and cleaning of the secondary channel louvers.

When the Facility is expanded to its ultimate capacity, an additional secondary channel will be constructed adjacent to and between the existing secondary and

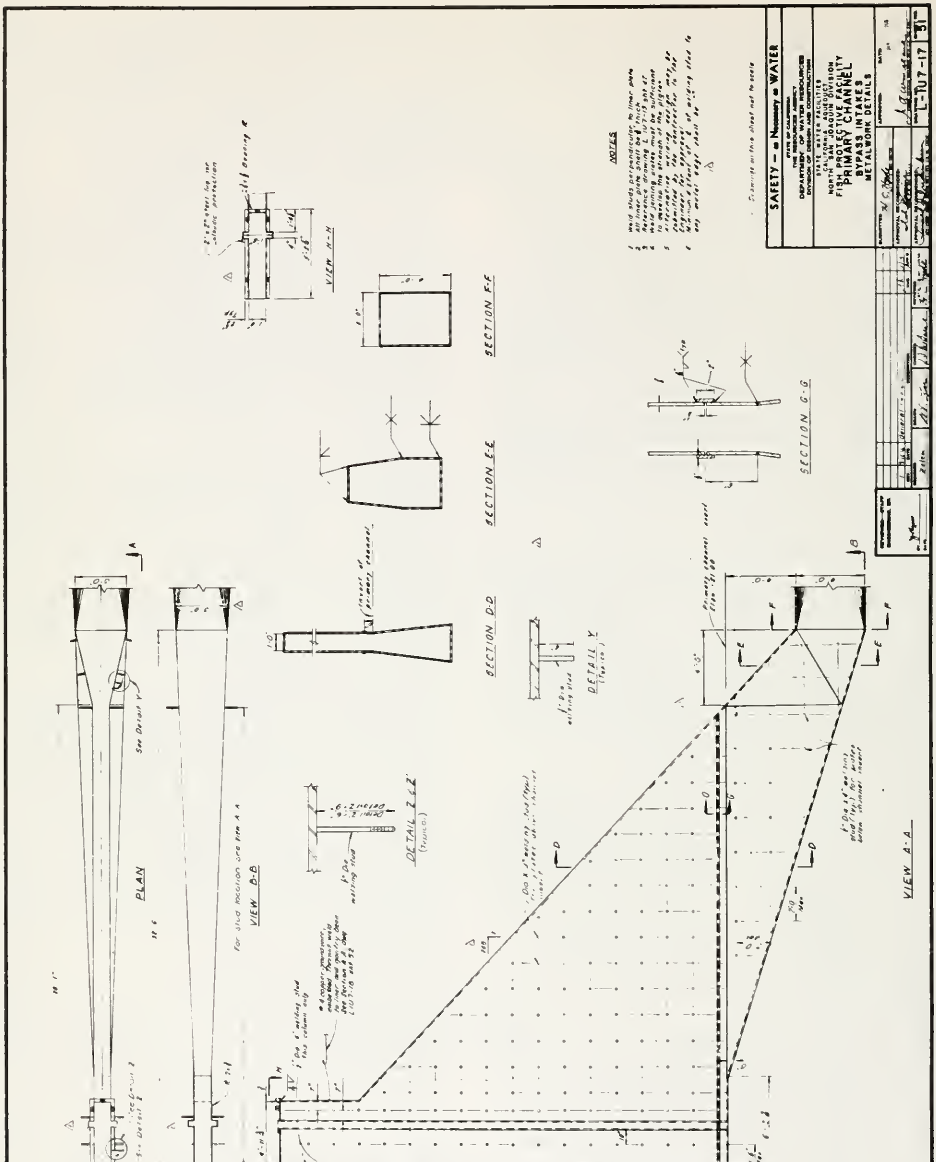


Figure 105. Primary Bypass Transitions

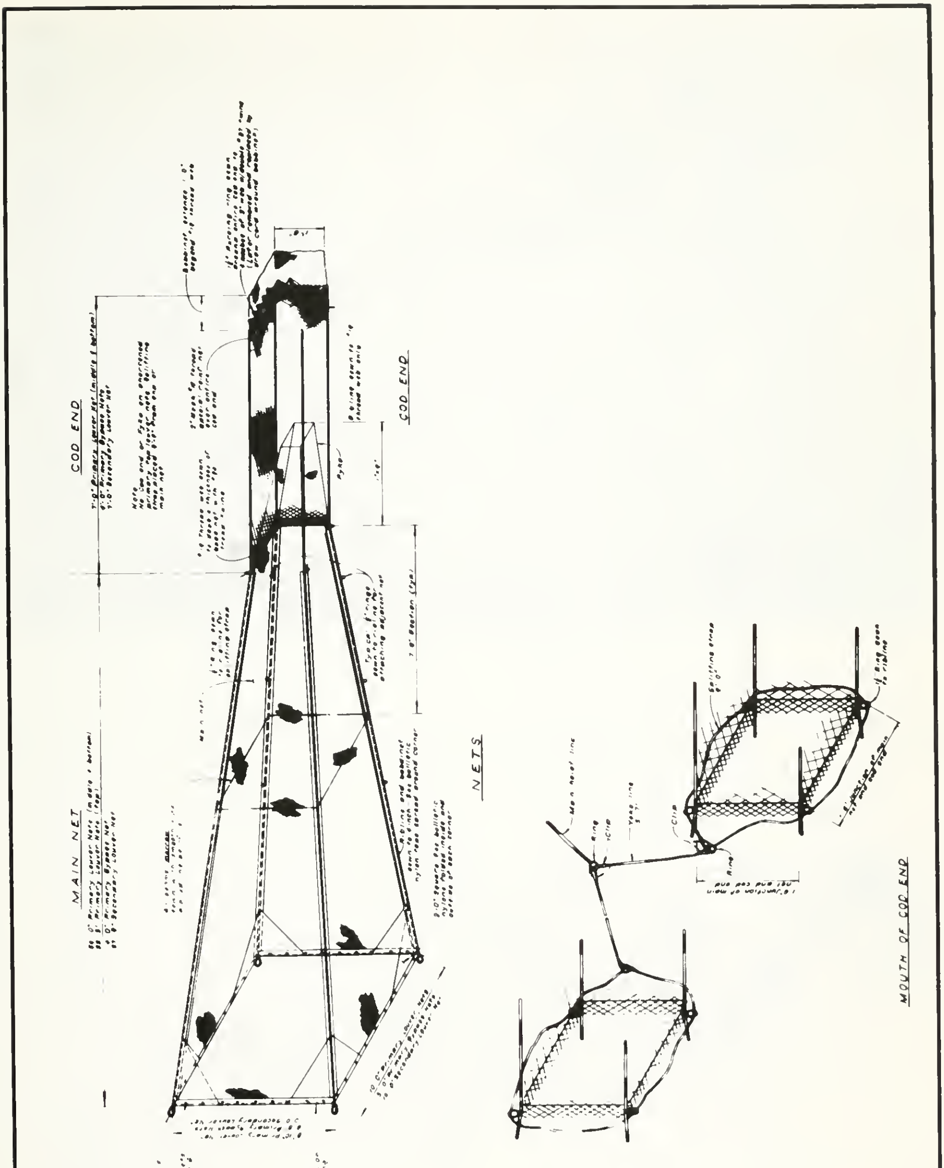


Figure 106. Test Nets

Figure 107. Gantry Crane

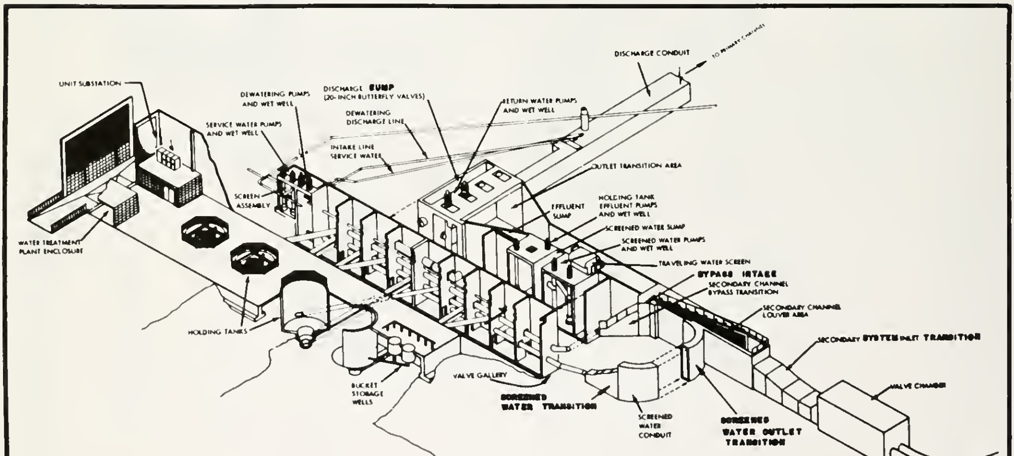


Figure 108. Secondary Channel Layout

primary channels. In order to accommodate future expansion, a pipe was installed beneath the existing secondary channel from the future secondary channel bypass to the holding tanks influent pipe. The right wall of the existing secondary channel also was designed for the unbalanced water load occurring upon removal of its backfill for the construction of the additional secondary channel.

Screened Water Transition and Conduit. A constant supply of screened water is required in the operation of the Delta Fish Protective Facility principally to facilitate the fish-screening function of the holding tanks. To produce this supply of screened water, a vertical-traveling water screen was installed in the left wall of the secondary channel outlet transition portion just downstream from the end of the louver area (Figure 109).

The screen was designed to operate for a five-minute period under an abnormal head differential of 2½ feet at 13½-foot channel depth. The driving motor can run continuously without overloading under normal flow conditions of a 0.4-foot water head differential, at an 11½-foot channel depth. A spray system is provided to wash the screen trays at a maximum operating pressure of 150 pounds per square inch.

The screened water system includes an intake wet well; a sump; a 24-inch steel pipeline with a flowmeter and regulating butterfly valve; and a metal-lined, reinforced concrete transition between the 24-inch steel pipe and the 8-inch by 10-foot rectangular vertical conduit. Screened water is introduced into the secondary channel 6½ feet upstream of the bypass, and this water transports the fish to the holding tanks through the bypass and the influent line. The screened water system is supplied by two 30-horsepower pump units, each discharging 22 cfs at 4-foot head. Flow is regulated by a 20-inch butterfly valve which also recirculates water back to the pump wet well.

Bypass Transition. The bypass transition is a reinforced concrete structure of the same configuration as the screened water transition. It forms a transition from a vertical, 6-inch-wide by 48-inch-high, rectangular conduit to a 24-inch-outside-diameter, steel pipe, influent line. Bypass intake metalwork forms the 6-inch-wide inlets. Overall length of this transition is approximately 22 feet.

Outlet Transition. The secondary channel outlet transition, a reinforced concrete structure situated between the louver area and the discharge conduit pumping plant, is approximately 77 feet in overall length. Channel configuration for the first 47 feet conforms to that of the louver area configuration, being 10 feet wide. The final 30 feet of the outlet transition channel increases in width from 10 feet to 39½ feet, with the invert sloping uniformly downward. Expansion joints are located at both ends of this transition.

Outlet Transition Sumps and Wet Wells. The outlet transition sumps and wet wells are comprised of the screened water intake wet well, screened water sump, effluent wet well, and effluent sump. All are an integral part of the outlet transition.

Valve Gallery. The valve gallery consists of two buried reinforced concrete structures with the centerline located 276 feet to the right and parallel to the centerline of the primary channel.

Secondary Piping and Hydraulics Description. The holding tank is prefilled to 1 foot above the top of the influent pipe before commencing the collection cycle in order to prevent injury to the fish entering the holding tank. This is accomplished by allowing water to flow by gravity from a full holding tank through its effluent line. Then screened water containing fish is taken from the secondary channel and transferred to an influent pipe which carries it to one of four holding tanks (Figure 110). In the holding tank, the water passes through a cylindrical screen, leaving the fish outside the screen. The water is discharged through the effluent pipe in the bottom of the holding tank. This process continues until the concentration of fish reaches a predetermined density dependent on fish size and water temperature.

After a holding period of variable length, the cylindrical screens are lifted 4 inches, the influent and the effluent valves are closed, and the dewatering valve is opened to lower the water level in the holding tank. Water flowing through the fish bucket in the dewatering wet well is pumped to the primary channel.

Influent Pipe. The standard steel, 24-inch-outside-diameter, influent pipe starts from the bypass transition; enters the valve gallery at the end wall of Bay No. 1; and extends into Bay No. 2, at which point the flow is measured by a tube-type meter (Figure 98). Immediately downstream of the meter, the 24-inch pipe is connected to a 30-inch-outside-diameter pipe, which extends along the valve gallery. From each of Bays 3, 5, 7, and 9, a 30-inch-outside-diameter pipe branches off to a holding tank. A 30-inch gate valve is located on each branch inside the valve gallery.

Effluent Pipe. Excess water from the collection cycle flows from each holding tank through an effluent pipe from the base of each holding tank to the main effluent pipe in the valve galley, and then to the effluent wet well in the outlet transition structure (Figure 111). Each branch effluent line from a holding tank consists of 24-inch-outside-diameter, standard steel pipe. Inside the valve gallery, the pipe connects to a butterfly valve which connects to the 24-inch-outside-diameter, standard steel, main effluent pipe located directly below the main influent pipe.

Dewatering Pipe. When the collection cycle is stopped at the holding tank, the effluent pipe valve is closed and the dewatering pipe valve is opened. The dewatering pipe allows the water surface in the holding tank to be lowered from the collection level down to a convenient volume for fish removal and also drains off overflow from the fish bucket.

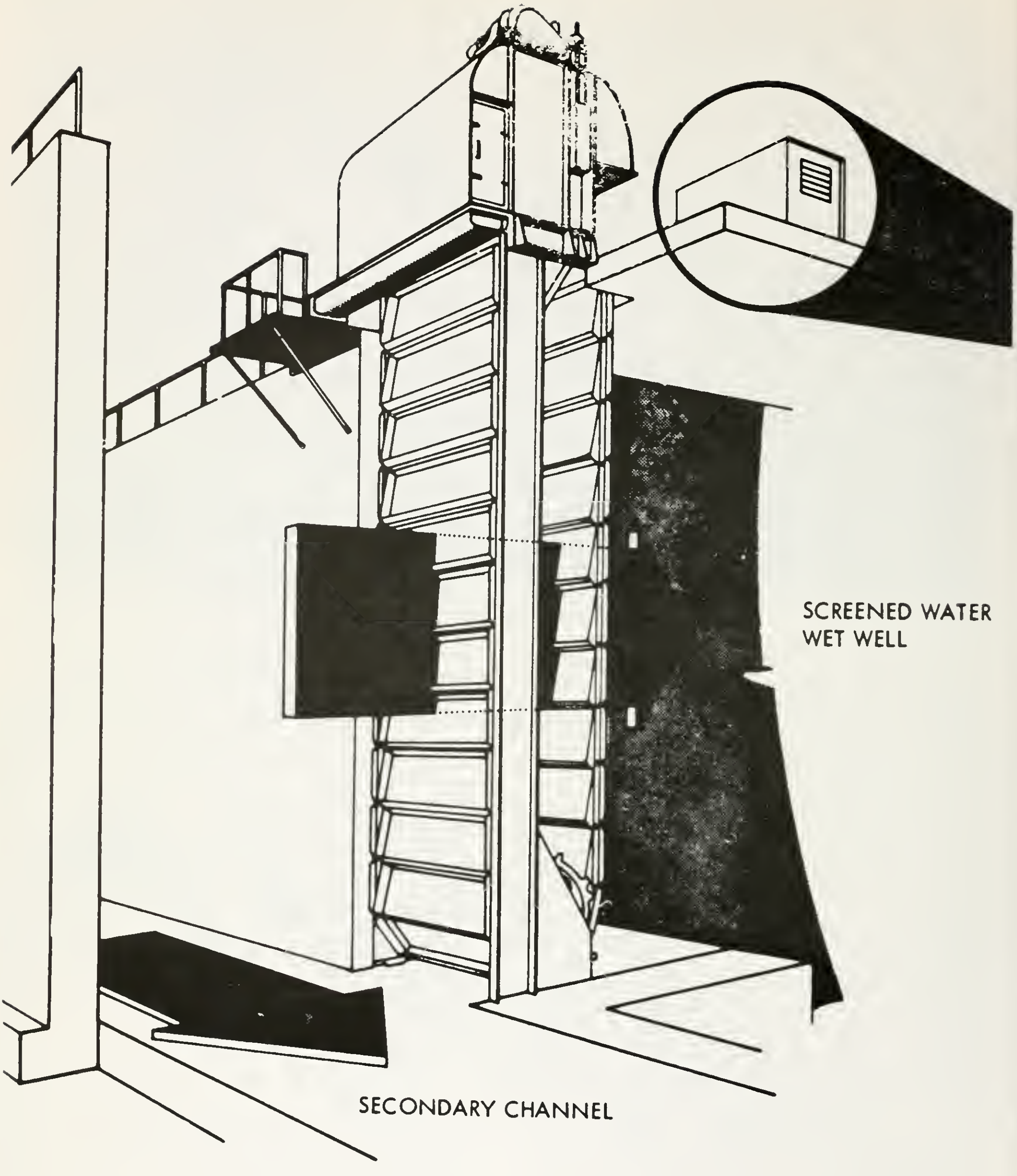


Figure 109. Traveling Water Screen

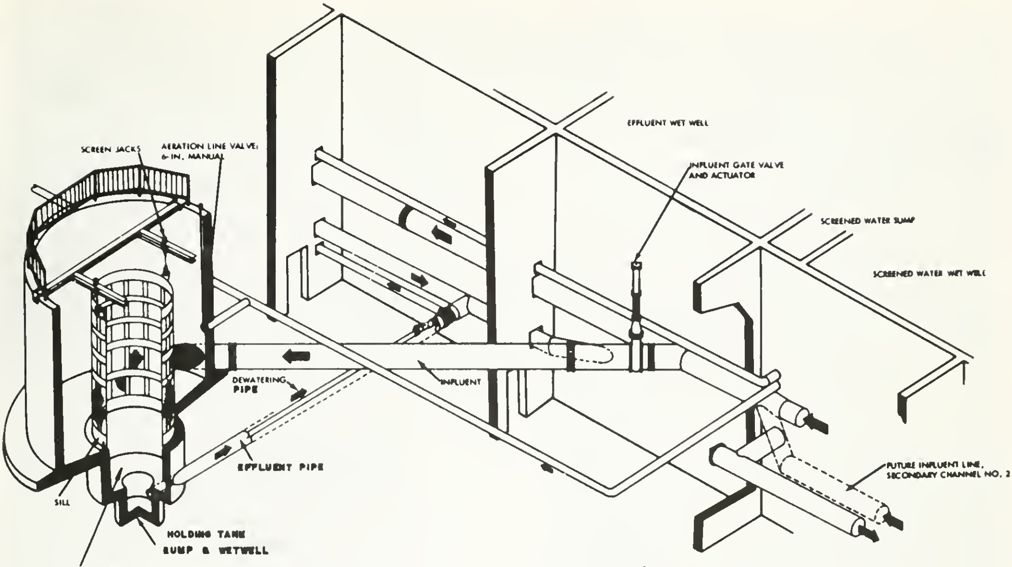


Figure 110. Valve Gallery and Holding Tank

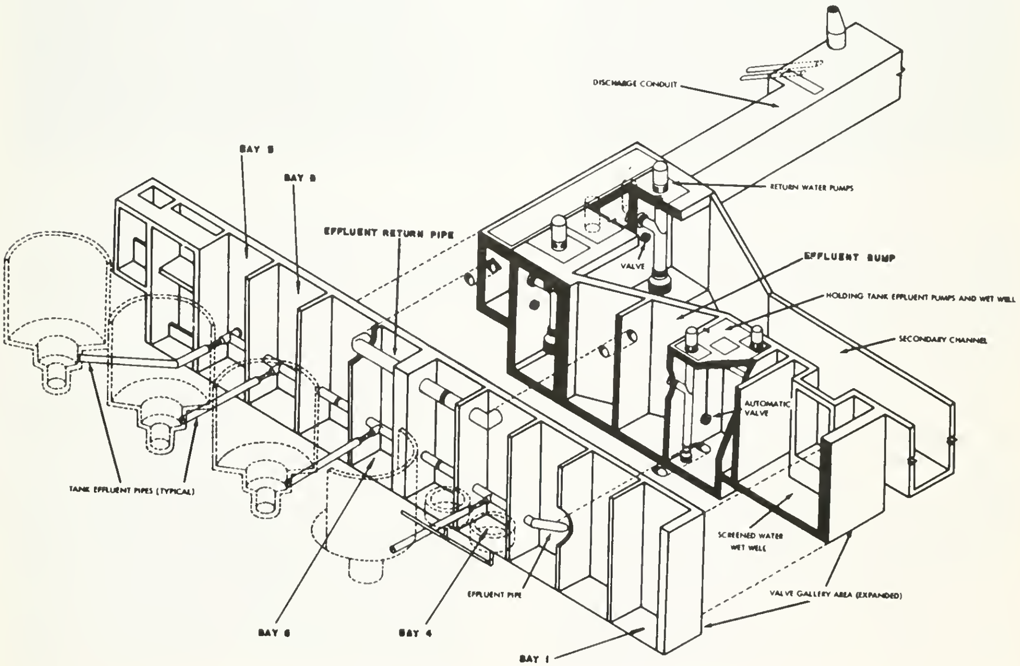


Figure 111. Effluent and Return Water Systems

Holding Tanks. Four cylindrical, reinforced concrete tanks are located 39 feet to the left of the valve gallery centerline (Figure 110). Each tank is 20 feet in diameter, has 10-inch-thick walls, and is 19½ feet deep. The bottom slopes for a total drop of 1 foot at the edge of the fish bucket well, which is 7 feet-8 inches in diameter and 4 feet deep. The bottom of the bucket well is sloped for a total drop of 0.33 of a foot to the top of the holding tank sump, which is 3 feet in diameter and 3 feet deep with a flat bottom.

The influent pipe enters through the wall of the holding tank, the effluent pipe exits at a right angle through the wall of the fish bucket well, and the dewatering pipe exits at a right angle through the wall of the holding tank sump.

Description of Discharge System. The pumping plant, discharge sump, and discharge conduit system serve integrally in regulating the flow through the secondary channel. It is necessary to maintain a balanced flow relationship of the secondary channel hydraulics with the primary channel hydraulics. Periodic adjustment to the system is required as the primary channel hydraulics is dependent on the Clifton Court Forebay water surface elevation, which in turn is dependent on tidal fluctuations and Delta Pumping Plant demand. Secondary channel flow is affected by primary channel water surface elevation, bypass piping and transition losses, and depth of water in the secondary return water pump sump. Regulation of secondary flow is achieved by the regulation valves in the bypass lines, the rate of pumping by the secondary return water pumps, and the return water valves. The system also serves to redeliver water passing through the secondary system back to the primary channel via the discharge conduit.

The Pumping Plant is a reinforced concrete structure located at the downstream end of the secondary channel outlet transition on a centerline coincident with the secondary channel, 248 feet to the right of the primary channel centerline. Four pump units, each delivering 59 cfs at 8 feet of head, are supported by the structure. Steel baffle plates are located on the invert floor directly behind each pump unit to prevent vortex formation.

Flow of the secondary channel is lifted by the pumps into the discharge sump from which the water returns to the primary channel through the discharge conduit. Regulation of flow to achieve required flow characteristics in the secondary channel is accomplished by pump selection and recirculation of water between the pump wet well and the discharge sump through three 20-inch butterfly valves.

The Pumping Plant can be drained below the pump bells, the discharge sump, and the discharge conduit with a portable sump pump stored at the site.

The reinforced concrete discharge sump is an open box structure 5 feet wide by 42½ feet long that slopes from the valve gallery wall to the discharge conduit. A 1-inch joint with a rubber waterstop and elastic filler separates the valve gallery from the retaining wall stem and toe. Drainage of the discharge sump can be accomplished by installing stoplogs in the stoplog structure located at the upstream end of the discharge conduit. The water surface in the discharge sump can then be lowered to within 6 inches of the invert by draining back through the butterfly valves into the pumping plant wet well. Remaining water can then be removed with the portable sump pump.

From the limits of the discharge sump, a temporary reinforced concrete conduit extends 44 feet toward the primary channel at a 90-degree angle to the pumping plant centerline. This section, separated at both ends by elastic-filled joints, will be replaced by another structure when planned future expansion takes place.

A permanent reinforced concrete conduit extends from the end of the temporary conduit to a cross-sectionally identical extension conduit cast integrally with the right side of the primary inlet transition. A 1-inch joint with elastic filler and a 9-inch rubber waterstop separate this conduit from the primary inlet transition extension.

Louver Assemblies

Aluminum alloy louver assemblies of closely spaced, parallel, vertical slats (Figure 112) direct fish from the primary and secondary channels into the respective bypasses. These slats are oriented perpendicular to the direction of flow. A line of the leading edges of these slats is approximately 15 degrees to the direction of flow in the channel. Water flowing downstream in the channel is turned 90 degrees to flow between the louver slats. Flow straighteners are provided to turn this water back downstream. Model studies indicated that a spacing of about 8 inches between flow straighteners minimized head loss.

The louver assemblies are arranged in a sawtooth pattern to span the primary channel. The total height of a louver assembly is 26 feet, allowing 1 foot of freeboard above the maximum normal operating water level. To facilitate handling, each primary louver assembly was fabricated by bolting together two 13-foot-high by 8-foot-wide sections.

Louver assembly sections used in the secondary channel are the same size as those used in the primary channel. The 13-foot-high panels satisfy the hydraulic conditions and allow 2 feet of freeboard.

Pipe sleeves were provided on the back of each louver assembly. The louver assemblies are held in position in the channel by sliding these pipe sleeves over the vertical support pipes in the channel. This method of support facilitates washing of the louvers which is done by lifting them vertically through high-pressure water jets mounted on the gantry crane without having to detach them from the support pipes.

Hydraulically, the louvers act similarly to a trash-

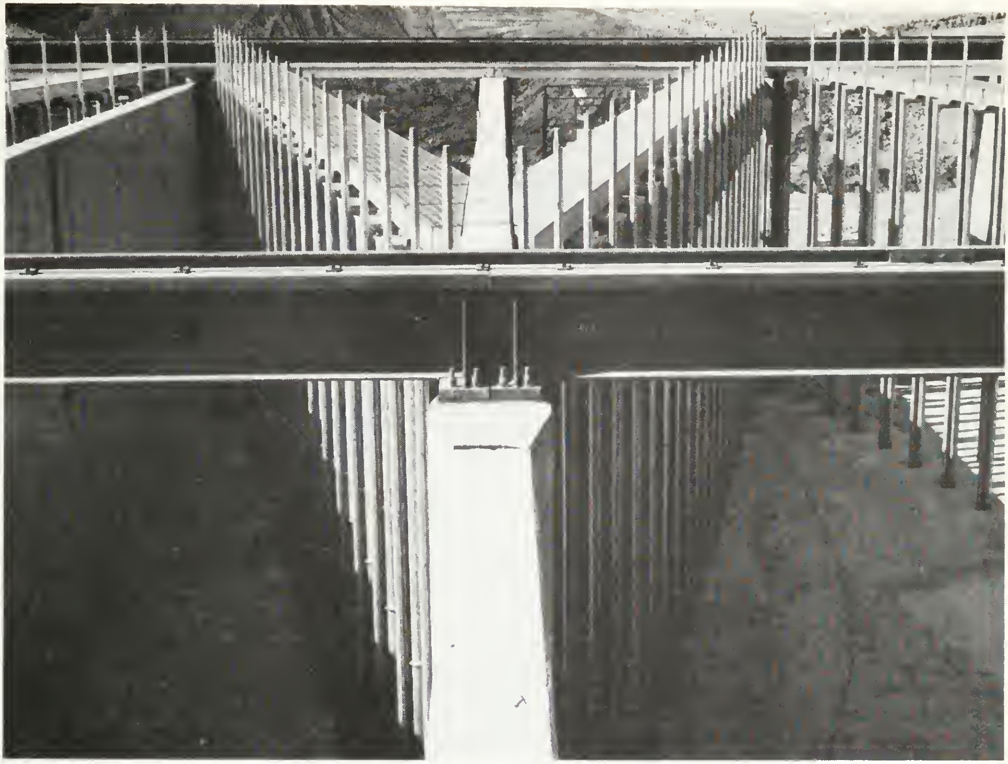


Figure 112. Louver Supports

rack. Head loss across the louvers is a function of the velocity in the channel and the amount of clogging by debris. One foot was established as the maximum allowable design head loss.

Control Air System

The control air system includes all pneumatic controls, air transmitters, air indicators, air recorders, air relays, directional control valves, lubricators, filters, strainers, the primary channel air dryer and reservoir tank, valves regulating compressed air flow, air reservoirs, electric pressure switches, air bubblers, and air bubbler lines. The system also includes all 3- to 15-pound-per-square-inch (psi) instruments and control air piping, 175-psi main air piping and 175-psi operator air piping, 25-psi control air supply piping, air pressure gauges, the control center panel board, the primary channel panel board, and the traveling water screen panel board. All valves are actuated by pneumatic cylinder operators utilizing air from the 175-psi main air system.

The pneumatic control system measures the water velocity in the channels in use in the primary channel and, in proportion to the velocity measured, performs the following:

1. Regulates the water flow to the secondary channel.
2. Measures the secondary channel flow and velocity.
3. Controls the pumping rate, limiting velocities and depth in the secondary channel.
4. Measures and controls the screened water pump capacity and flow rate.
5. Measures and controls the holding tank capacity and flow rate.
6. Activates the screened water washing system.
7. Turns the pumps on and off according to limiting water depths.

Pneumatic Cylinders

Pneumatic cylinders operate the control gates and jacks to lift the holding tank screens. Primary channel control gates are operated by a pneumatic cylinder capable of producing a minimum force of 12,500 pounds when supplied with 150-psi air.

Service Water System

Two hydropneumatic pressure tanks were designed to operate in parallel at a design working pressure of 150 psi. Two pressure switches were furnished with each tank to control the two service water pumps on an alternating basis with an override feature that allows both pumps to operate on line during high demand periods.

Temporary Supply Channel

The temporary supply channel was a waterway bypassing the Delta Fish Protective Facility site during construction. The waterway, with the California Aqueduct intake channel serving as a storage reservoir, was designed to meet an off-peak flow demand of 350 cfs for the South Bay Aqueduct.

The temporary supply channel consisted of an inlet transition and an open ditch containing two parallel, 78-inch, corrugated metal pipes and an outlet transition. Corrugated metal pipe was utilized to prevent saturation of the slope adjacent to the construction site.

Flow was toward Delta Pumping Plant during high tide and was stored in the intake channel for pumping during low tides. Flap gates prevented reverse flow. Slide gates were installed on the upstream ends of the pipes to isolate the downstream reach of the intake channel.

Upon completion of the facility to the point of passing flow through the primary channel, the temporary supply system was dismantled and obliterated.

Construction

Contract Administration

General information for the major contracts for the construction of the Delta Fish Protective Facility is shown in Table 4. The principal contract for the Facility was designated Specification No. 66-06. Louvers, pumps, gantry, net frame, and testing equipment were supplied under separate contracts.

TABLE 4
Major Contracts
Delta Fish Protective Facility

	Fish Protective Facility	Furnish Louver Assemblies	Pumping Units	Gantry Crane	Net Frames and Supports for Evaluation Testing	Evaluation Testing Equipment
Specification	66-06	66-20	66-40	66-45	68-51	69-08
Low Bid Amount	$4,163,524	$172,200	$107,877	$187,550	$9,871	$88,602
Final Contract Cost	$4,766,225	$181,367	$113,488	$199,070	$9,164	$91,054
Total Cost–Change Orders	$277,175	$300	$1,296	$2,200	—0—	$2,198
Starting Date	5/26/66	6/30/66	11/1/66	12/9/66	9/10/68	5/12/69
Completion Date	8/30/68	2/20/68	6/11/68	11/6/68	11/26/68	1/20/70
Prime Contractor	Rothschild, Raffin & Weirich and Rothschild, Raffin & Weirich, Inc.	Conlin & Roberts Metal Products	Johnston Pump Co.	Pacific Coast Engineering Co.	R. W. Hubbard Co.	Von Raesfield Engineering Construction

An aerial view of the Delta Fish Protective Facility during construction is shown on Figure 113.

Temporary Supply Channel and Primary Channel Excavation

Primary channel excavation began in the fall of 1965 when material from the site of the Delta Fish Protective Facility was used for embankment of the California Aqueduct intake channel under Specification No. 65-07. Construction forces arrived at the site on June 6, 1966 and commenced excavation of the temporary supply bypass channel. Excavation proceeded in the summer of 1966 and was 80% complete by October 1966. The channel was completed a year later after concrete placement in the primary channel had progressed sufficiently to permit backfilling behind the counterfort walls.

Secondary System Excavation

Secondary system excavation commenced in July 1966 and continued through October 1966, when approximately 90% was completed. Excavation for the holding tanks, valve gallery, valve chamber, and bypass pipelines A, B, C, and D was included. Excavation for the discharge conduit and the deep sumps for the dewatering system was completed by May 1967.

The 64,000 cubic yards removed in the excavation

Figure 113. Aerial View of Fish Protective Facility

were stockpiled in adjacent areas for backfill. Rainfall eroded material from the slopes into the excavation, resulting in enlargement of the excavated site and the importation of aggregate drain material to facilitate stability and compaction. Overexcavation at the secondary system screened water transition destroyed a portion of the control building site, requiring replacement with compacted backfill. Excavation was mostly on a ¾:1 slope.

Compacted Embankment

Compacted embankment used in the access roads was obtained from selected material available from excavations. The material was placed in layers and compacted with a single-drum sheepsfoot roller. After compaction and before paving, the contractor used these roads for construction purposes.

Compacted Backfill

Compacted backfill was placed in secondary system trenches, mainly during the late summer of 1967. Heavy rains in 1966–67 partially refilled the excavations for the secondary structures with silty clay necessitating reexcavation. In many cases, the contractor found aggregate base to be the solution to this problem of wet conditions.

Besides creating sloughing of cut slopes, the heavy rains kept stockpiled backfill material overly wet, and a 25% moisture content was common. Selective loading around the perimeter of piles was utilized to allow the evaporation of excess moisture.

Pervious Backfill

A total of 24,000 cubic yards of pervious backfill material was placed during the fall and winter of 1966. This material was hauled to the site in bottom-dump trailers and spread by dragline and dozers behind the counterfort and transition walls. Where possible, the material was placed directly in final position and handled as little as possible to avoid segregation.

After initial filling of the California Aqueduct intake channel in September 1967, the pervious material behind the primary channel walls settled more than anticipated, resulting in damage to completed items, such as electrical conduit and adjacent concrete features. Backfill was added and jetted to obtain maximum settlement, and the damaged features were repaired or replaced.

Pervious backfill material also was used as underlayment for the stone slope protection in the inlet and outlet transition channels. A 6-inch layer was spread over a 2-inch layer of filter blanket material and topped by a 1-foot to 1-½-foot layer of stone. Pervious backfill material also was placed in the trenches beneath the floor of the primary channel.

Rehandle Material Placed in Stockpiles

During 1966 and 1967, a total of 103,000 cubic yards of material previously placed in stockpiles was rehandled and used for (1) backfill around the temporary supply cutoff collars, (2) backfill around the 78-inch temporary supply pipes, (3) the embankment of an access road, (4) the levees separating a settling pond from the construction site, and (5) backfilling the temporary supply channel after removal of the pipes. All of this material was moved with self-loading scrapers.

Overhaul Material

A total of 2,425,000 station-yards of overhaul was required to haul material excavated from borrow areas and excavated material directed to waste.

Stone Slope Protection

During September and October 1966, approximately 1,300 tons of stone slope protection was placed at the inlet and outlet transitions of the temporary supply channel. During July and August 1967, when the primary channel structure was completed, a total of 8,488 tons was placed at the inlet and outlet transitions. Material was trucked to the site, dumped in large piles, and then spread into final position by a dozer. Piles were moved en masse to minimize segregation.

Underwater Stone Protection. During September and October 1967, stone protection was placed at the temporary downstream supply plug after its completion and, during March and April 1968, at the upstream plug when it was sufficiently excavated to allow placement. This material was placed by a crane rigged with a 1½-cubic-yard clamshell bucket. Slope protection for both sections that tied into the Aqueduct was completed by the aqueduct contractor.

Dewatering Operations

Dewatering was necessary on a 24-hour basis during the entire construction period. During the construction of the California Aqueduct intake channel to the Delta Pumping Plant, a pit approximately 550 feet long and 250 feet wide at the top had been excavated for borrow at the site of the Delta Fish Protective Facility. In June 1966, the contractor for the Delta Fish Protective Facility commenced dewatering this borrow pit by pumping water into a sump near Clifton Court Road. After the initial filling of the California Aqueduct intake channel in January 1967, water from the sump was released into the Aqueduct.

Other problems in dewatering arose when, in November 1966, a temporary supply pipe ruptured, partially flooding the temporary supply channel. A dewatering system was installed to prevent the escaped water from entering the same strata interconnected with the primary channel excavation. Also, after initial filling of the California Aqueduct intake channel, water passing through the sand strata from that source made the excavated slope for the primary channel structure unstable. The excavation contractor for the Delta Fish Protective Facility placed pervious material on the wet areas to stop piping and to stabilize the slopes.

Rains in 1966–67 also created dewatering problems. Some excavations were pumped out several times before concrete could be placed. Three-, five-, and seven-horsepower electric pumps, set in 24-inch perforated casings backfilled with drain rock, were used.

Stoplogs

Redwood timber stoplogs were fabricated in May 1967 and installed during June 1967 before filling the primary channel. When the contractor installed the stoplogs, they floated, and large weights and steel pins were used to properly position and retain the stoplogs.

Walkways

The timber access walkway to the slide gates in the temporary supply channel was constructed during September 1966. During the winter of 1966–67, heavy rains and high tides inundated this structure, forcing the crews to wade through nearly 1 foot of water to reach the slide gate operators. The walkway and temporary supply pipes were removed later.

Concrete Pipe

From May through July 1967, a total of 361 feet of 54-inch-diameter reinforced concrete pipe (RCP) and 709 lineal feet of 48-inch-diameter RCP were placed for the primary channel bypass.

Primary Channel Bypass Pipes Bulkhead

The primary channel bypass pipes bulkhead was installed at the end of the two 48-inch RCP lines at the future valve chamber location. A 12-inch, concrete, access pipe extends to the ground surface with a reference marker for future construction.

Asbestos Cement Pipe

In November and December 1966, a 4-inch asbestos cement pipe was installed to drain the valve chamber into the valve gallery. Persistent rains made working conditions difficult, but the installation was necessary before concrete placements could begin.

Temporary Supply Channel and Drainage Facilities

Corrugated Metal Pipe. The 78-inch pipes were installed in the temporary supply channel during the fall of 1966. A 12-inch corrugated metal pipe (CMP) was installed for drainage along the temporary supply pipes during the winter of 1966–67.

Excavation of the California Aqueduct intake channel downstream of the Delta Fish Protective Facility was behind schedule, and seepage from the filled temporary supply channel might have further delayed the excavation. Accordingly, the temporary supply channel was not placed in service immediately upon completion.

After removing the upstream plug in October 1967, the CMP was removed.

Temporary Supply Cutoff Collar. The temporary supply cutoff collar included an 8-inch-wide CMP collar fitted around the 78-inch-diameter CMP and a bentonite clay plug 6 feet wide and 10 feet high placed near the inlet structure of the temporary supply. Excavation and placement of the bentonite clay seal was performed during August 1966.

Steel Pipe

Steel pipe was used in the screened water, influent, effluent, aeration, dewatering, service water supply, and floor drainage systems and for the 36-inch-diameter return water discharge pipe. Pipe was first installed in November 1966 for the holding tank effluent line. Installation proceeded slowly throughout the winter. In March 1968, one of the 16-inch dewatering pipes failed under the pressure of the effluent pump, slowing progress until the pipe was welded and concrete encased.

Flap Gates and Slide Gate

Flap gates and a slide gate were installed on the outlet pipes and inlet structure, respectively, of the 78-inch temporary supply line in August 1966 without incident. A 36-inch slide gate was installed in July 1967 at the end of the 36-inch return water discharge pipe.

Steel Sheet Piling

Step-tapered, interlocking, steel sheet piles were driven along the perimeter and encased by the key concrete of the primary channel structure. Placement began in September 1966. Steel walers were used for guides. When ground resistance was first encountered, the pillow block was damaged. On September 15, 1966, the contractor substituted a vibratory hammer, which initially drove the piling much faster until more resistant strata were encountered. Based upon this experience, the Department authorized a reduction in the required penetration from 40 to 30 feet.

Pile-driving operations on the south side of the primary channel structure were initially easier but, as the driving operation proceeded in a northerly direction, the resistant strata again were encountered and several piles were left at refusal.

Concrete Construction

Concrete was mixed at the site in a batch plant having a 600-barrel cement silo and a 4-cubic-yard mixer. The mix was transported in concrete trucks modified to handle the required low slumps.

Because of its durability and reuse characteristics, high-density plywood was used for formwork. Forming for the primary channel and counterfort walls (Figure 114) was routine, but the forming for the secondary channel and the primary inlet and outlet transition walls was more complicated.

The primary channel inlet transition slab was constructed directly on pervious backfill using a slip form paver.

Difficulties. Concrete in the sloping portion of the counterfort walls was vibrated from access openings cut in forms. Pencil vibrators were used.

Prior to the filling of the California Aqueduct intake channel, the contractor was instructed to go over his work and repair rock pockets, joints, and gummy patches. On filling the secondary channel, concrete failures appeared. The channel was pumped out, and the concrete was replaced or repaired. In the course of repair, damaged waterstops were exposed in the joints of the discharge conduit, pumping plant, and louver supports. In some cases, the waterstops were completely folded. The concrete was removed entirely, waterstop straightened, reinforcing steel cleaned and respaced, and concrete replaced.

Complications in the placement of the holding tank building precast panels resulted from the inconvenient location of the casting yard and because no metal was imbedded in the bottom edge of the panels. As the panels were barred into place, pieces of the wall chipped off and required repair.

Floating Trash Boom

In August 1967, teflon-coated steel guides were installed in the trash boom right bank structure and the trash conveyor pit. Installation of the floating trash boom was completed in March 1968 (Figure 115). Prior to site delivery, all flotation elements of the trash boom were hydrostatically tested at 10 psi for one hour.

Control Gates

Prior to filling the primary channel, the wall tolerances at the control gate locations were checked, and adjustments by chipping and grinding were necessary. Upon installation, some gates would not close until further corrections were made.

Holding Tank Screens and Fish Buckets

Four screens (Figure 116), a fish counting bucket, and a fish transport bucket were tested in the holding tanks in August 1967.

Upon initial operation, the fish counting bucket was modified by installing a guide system for controlling the entry angle at the fish bucket sump (Figure 116). The screens and the counting and transporting buckets required minor adjustments to prevent loss of fish.

Butterfly Valves

The 48-inch butterfly valves were installed in the valve chamber in May 1967. Both pneumatically and manually operated butterfly valves were used. Valves 24 inches and larger were used in controlling water containing fish.

Monorail Hoist

The 5-ton electric monorail hoist used for lifting the fish buckets in the holding tank building suffered repeated mechanical failures caused by the extension arm at the hoist. Removal of the arm corrected the problem.

Trash Conveyor

Pervious backfill material around the primary channel structure settled during the filling of the California Aqueduct intake channel, displacing the trash conveyor pit. The trash conveyor was releveled by modifying the legs of the conveyor support.

Project Accomplishments

The number of fish excluded from the California Aqueduct by the Delta Fish Protective Facility is dependent on many factors, the most significant probably being the Delta fish population during pumping periods. Fish salvage has varied from a high of 26,615,000 in 1970 to a low of 14,878,000 in 1973.

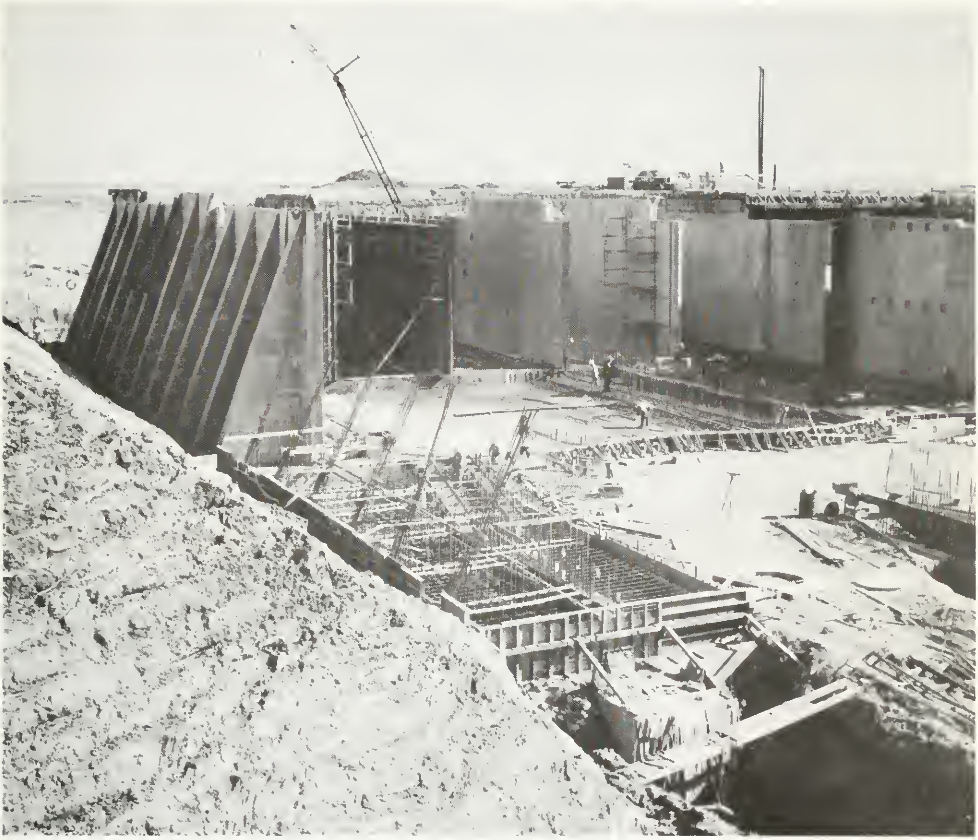


Figure 114. Primory Chonnel Construction

Figure 115. Trash Boom

Figure 116. Holding Tank Screen

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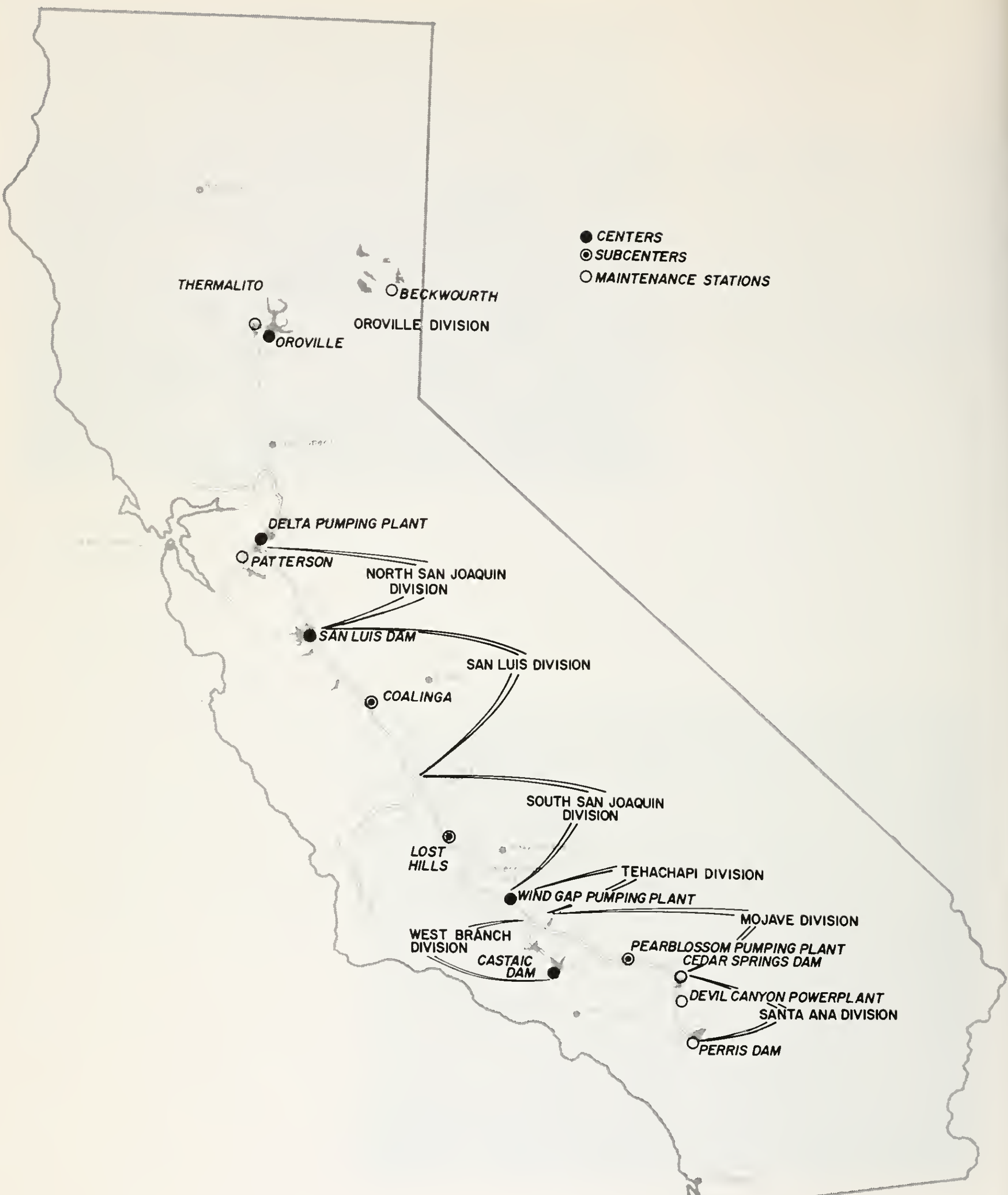

Figure 117. Location Map—Operations and Maintenance Facilities

CHAPTER VIII. OPERATIONS AND MAINTENANCE FACILITIES

General

The State Water Project extends over a vast geographic area encompassing extreme ranges of topographic and climatic conditions. The scope of operations and maintenance functions covers practically every problem encountered in the field of power and water delivery. Complex operation, maintenance, and repair functions place large demands on the personnel who man these facilities. Generating units which each produce up to 117,000 kilowatts and pumping units requiring up to 80,000 horsepower each must be operated and maintained. Control systems, sensitive surveillance instrumentation in dams, and many other electronic systems require close attention. Tumbleweeds must be cleared from the aqueducts and pondweed harvested from shallow forebays. Turnouts must be monitored and many other day-to-day demands must be met to keep the system delivering water and power on schedule.

Operations and maintenance facilities are provided for personnel serving the many dams, reservoirs, canals, pipelines, pumping plants, power plants, operating roads, and communication network systems of the State Water Project. Studies indicated that a viable operating and maintenance network consisting of an extensive complex of buildings is required for the personnel to operate and maintain this huge water utility. Because workmen's wages constitute a major part of the operating budget, it is important that travel time between building complexes and work areas not be excessive. Operations studies concluded that maintenance building complexes should be located not farther apart than about 60 miles. With minor variations, this was used as a basic guideline in establishing the locations of the complexes.

Organization and Location

The overall management is administered from the Sacramento Headquarters of the Division of Operations and Maintenance located on the 16th floor of the Resources Building. Operations and maintenance activities of five Field Divisions are coordinated and controlled from this point.

Three classes of maintenance building complexes were constructed: Field Division Operations and Maintenance Centers with a full range of capability; subcenters with a partial range of capability; and small, single-purpose, maintenance stations with limited capability.

Where possible, the Field Division Operations and Maintenance Centers are located close to major features of the Project, i.e., a dam or plant (Figure 117). Locations also had to reflect Field Division boundaries since each is a separately administered group. The Field Divisions are as follows:

1. Oroville Field Division is responsible for the Oroville complex and Upper Feather River dams and reservoirs. The Center which serves this Field Division is located in Oroville at Glen Drive.
2. Delta Field Division is responsible for the California Aqueduct down to the northern end of the Federal-State joint-use facilities near Los Banos. This Division also includes the South Bay Aqueduct and North Bay Aqueduct. The Center which serves this Field Division is located at Delta Pumping Plant.
3. San Luis Field Division is responsible for the Federal-State joint-use facilities. The Center which serves this Field Division is located at San Luis Dam.
4. San Joaquin Field Division is responsible for facilities extending from the southern end of the Federal-State joint-use facilities at Kettleman City through the A. D. Edmonston Pumping Plant discharge lines and includes the Coastal Branch Aqueduct. The Center which serves this Field Division is located at Wind Gap Pumping Plant.
5. Southern Field Division is responsible for facilities extending from the A. D. Edmonston Pumping Plant discharge lines, through the Tehachapi Crossing, to Perris Dam on the "main line" California Aqueduct, and to Castaic Dam on the West Branch. The Center which serves this Field Division is located at Castaic Dam.

Subcenters are located on the Aqueduct near Lost Hills and Coalinga, and at Pearblossom Pumping Plant. Maintenance stations are located at the following sites:

Beckwourth (Upper Feather River dams and reservoirs)
Patterson (South Bay Aqueduct)
Thermalito Powerplant
Cedar Springs Dam
Perris Dam
Devil Canyon Powerplant

Function

Approximately 720 employees are stationed in the five Field Divisions and 130 employees in the Sacramento Operations and Maintenance Headquarters. Functional areas in the Field Divisions are broadly divided as follows: administration, engineering, plant maintenance, civil maintenance, and water operations.

Maintenance buildings provide the working space to support the functional activities listed. Field Division Operations and Maintenance Centers (Figures 118 and 119) provide the full range of functional capability. Subcenters provide a civil maintenance capability and a portion of the administration and water operations capabilities (Figures 120, 121, and 122). Maintenance stations generally provide partial capability in civil maintenance and water operations. However, with the wide scope of project activities and functions, each operations facility is tailored to meet the needs of its specific area.

Figure 118. Entrance to Delta Operations and Maintenance Center

Figure 119. Typical Civil Maintenance Headquarters Building

Figure 120. Typical Vehicle Maintenance Building

Figure 121. Interior of Vehicle Maintenance Building

Figure 122. Coalinga Operations and Maintenance Warehouse

Design Criteria

Architectural

The architectural motif for the operations and maintenance buildings is described in Chapter IV of this volume.

The basic criteria used in developing the project motif included the following considerations:

1. Durability of the facilities.
2. Low annual maintenance with respect to a 50-year projected life.
3. Strong structural form to contrast with nature's free form.
4. Pleasing and uniform appearance accented with bold colors.
5. Functionally usable to efficiently accomplish the operations and maintenance tasks.
6. Pleasant and comfortable working conditions.

Primary building materials consist of exposed steel frames; split-face, hollow, concrete blocks; cast-in-place concrete panels; precast concrete panels; and metal-clad panels finished with paint or porcelain. Windows having aluminum framing and mullions were used in office areas to provide employees with natural light and a view of natural and landscaped areas.

Functional design standards for occupancy and exit requirements meet those established by the Uniform Building Code (UBC). The UBC also was adhered to with respect to fire protection requirements.

Structural

The UBC was used as the basic design standard. Special consideration involving seismic design was given in control rooms and in areas where high seismic activity might be expected. Special consideration also was given in areas where wind was a factor. High winds are prevalent at San Luis, and the "Santa Anas" (hot desert winds blowing toward the ocean) are common in the Southern Field Division area.

Steel design was based on the UBC and the American Institute of Steel Construction manuals. Concrete design was based on UBC and American Concrete Institute recommendations. All applicable California Administrative Code title provisions were met, and building plans were reviewed in the Office of State Fire Marshal.

Civil Features

Site development was necessary for all complexes, and most locations required full utility and road development, as well as site grading and paving. Earthwork was accomplished under Department of Water Resources' standards. Base material, asphaltic concrete paving, concrete curbs, and traffic control generally conformed to the State Department of Public Works, Division of Highways (now the Department of Transportation) "Standard Specifications".

All utility distribution piping (sewer, water, gas, etc.) and conduit (electrical and communication) were installed underground for esthetic benefit and to ensure equipment operation safety. These systems include sewer collection, water distribution, electrical distribution, and telephone and other communication facilities.

Sanitary sewerage collection systems were required at all locations and all required treatment facilities except Oroville, which is served by the City of Oroville's treatment facility. These installed systems have septic tanks with leaching systems, either fields or pits. Each was submitted to a regional water quality control board for review and approval. Local government agency approvals were obtained through regional boards.

Site development was designed to function with the buildings to control traffic and separate unrelated work activities. Planters were provided for landscaping to beautify and to add screening.

In addition to the features already discussed, centers are equipped with filling stations, loading ramps for heavy equipment, water-truck fill stations for weed control activities, and corporation yards for storing material and equipment.

Mechanical and Electrical

Office space in the buildings is heated and air-conditioned. Some of the storage space is air-conditioned where stored and housed equipment or spare parts require environmental control. Initially, shop spaces were cooled with evaporative coolers and heated with space heaters. Shops now are being converted into central air-conditioned space.

The National Electric Code was used to supplement the requirements of the UBC, Public Utility Commission's General Orders, and California Administrative Code Title 24 and Title 8 (Electrical Safety Orders) requirements. The National Plumbing Code was used to supplement the requirements of California Administrative Code Title 24, UBC, and local codes.

Electrical service for the building complexes is provided from a plant station service where the electrical energy supplier's contract permits. This provides the lowest cost energy available. When plant station service is not available, service is purchased from the local supplier.

When local water companies are not available to provide domestic water, water treatment facilities are included in the physical plant. Plans for these facilities were submitted to local health officials for approval and were reviewed by state health officials. When possible, water treatment plants are sized to provide domestic water for the adjacent plants as well as for the complexes.

Samples of Center Layout and Buildings

The following selected drawings show a typical Field Division Operations and Maintenance Center, subcenter, and maintenance station.

Figures 123 through 134 cover features of a Field Division Operations and Maintenance Center. The Center shown is at Oroville and is located approximately 3 miles from Oroville Dam.

Figures 135 through 143 depict a subcenter adjacent to the California Aqueduct in the San Joaquin Valley. The subcenter shown is Coalinga (renamed from Five Points during construction). Figures 144, 145, and 146 are of the maintenance station at Thermalito Powerplant.

Additional facilities at the San Joaquin Field Division and Southern Field Division Operations and Maintenance Centers will be constructed to complete buildings previously deferred.

The following engineering drawings may be found in consecutive order immediately after this reference (Figures 123 through 146).

Figure Number

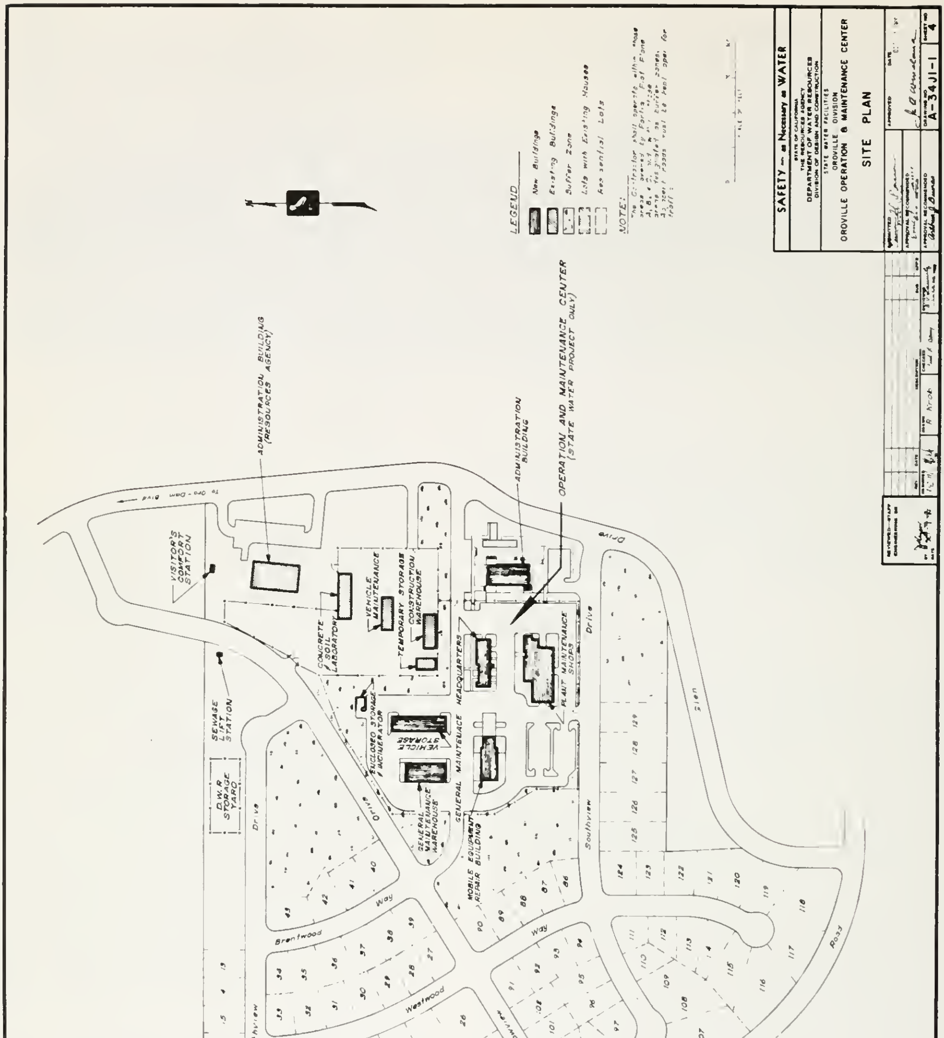

Figure 123. Oroville Operations and Maintenance Center—Site Plan

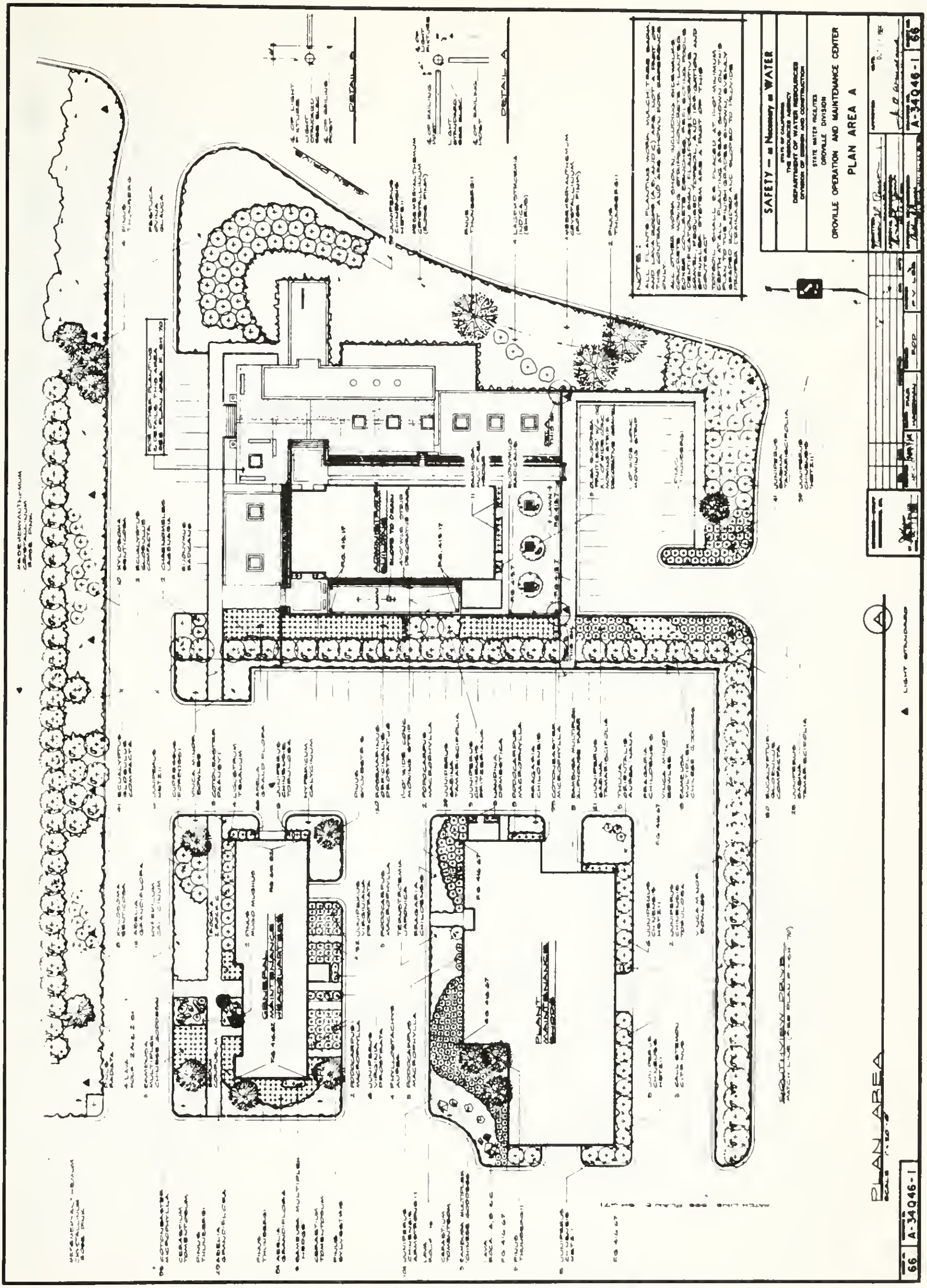

Figure 124. Oroville Operations and Maintenance Center—Plan Area A

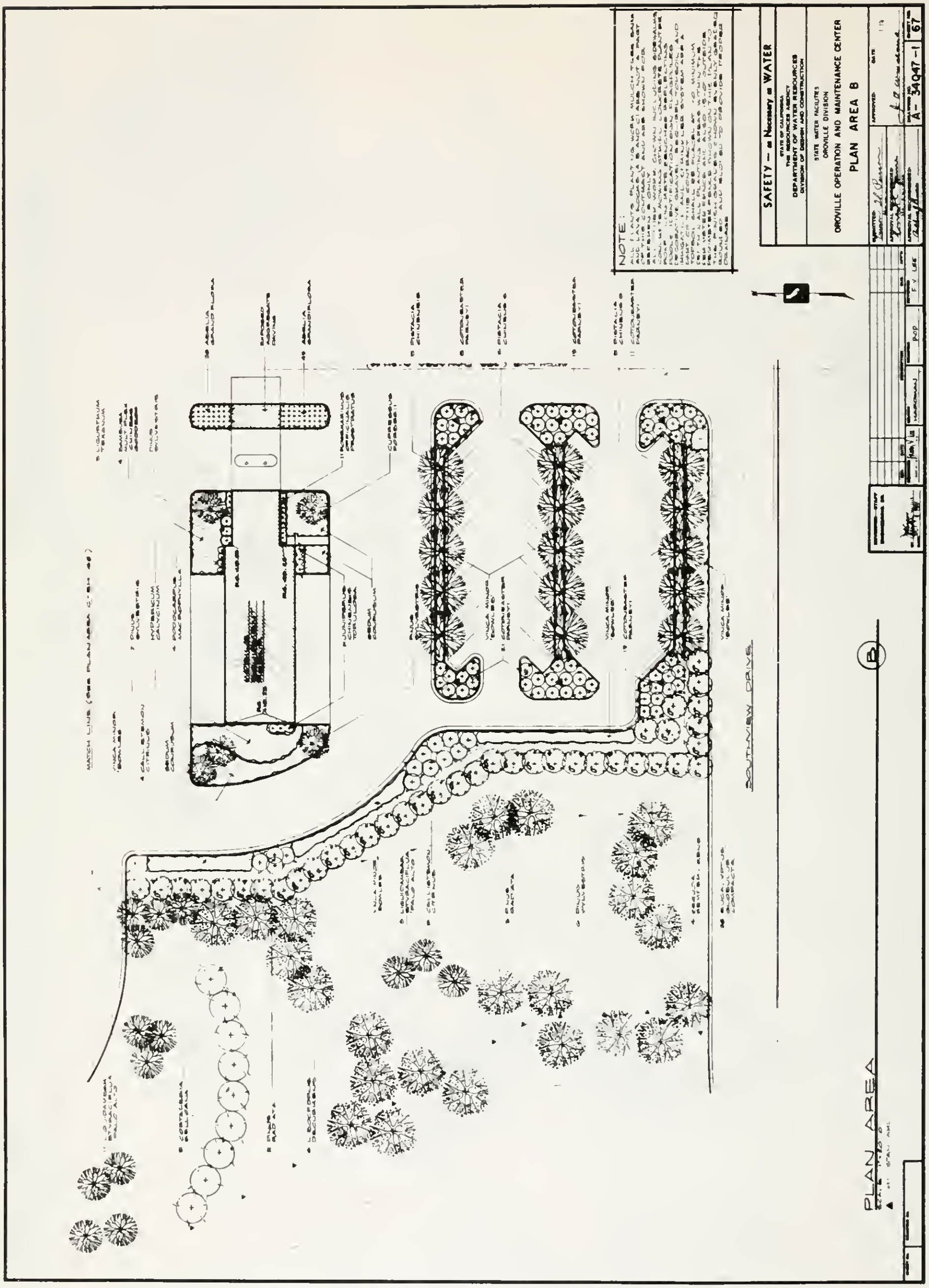

Figure 125. Oroville Operations and Maintenance Center—Plan Area B

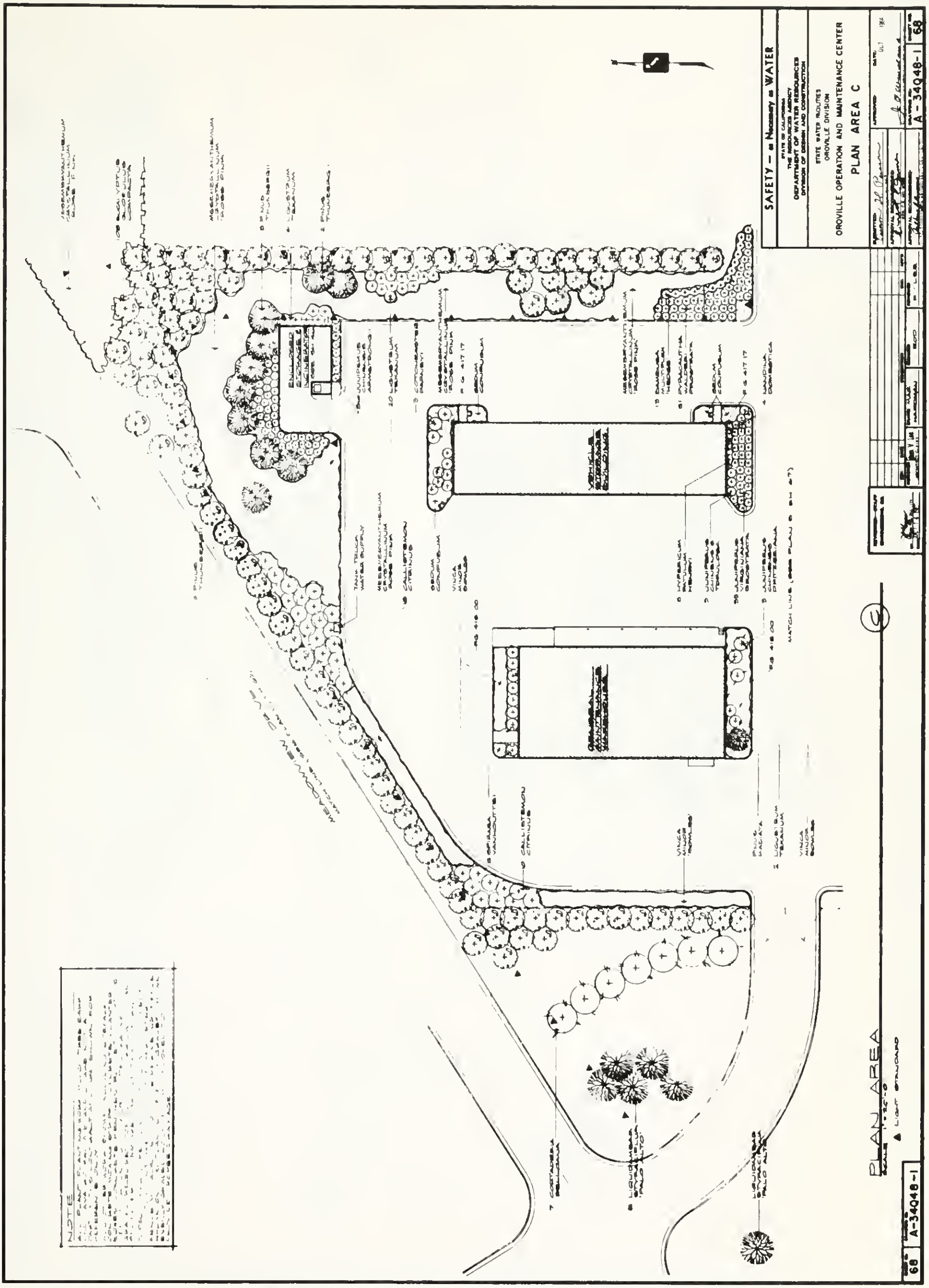

Figure 126. Oroville Operations and Maintenance Center—Plan Area C

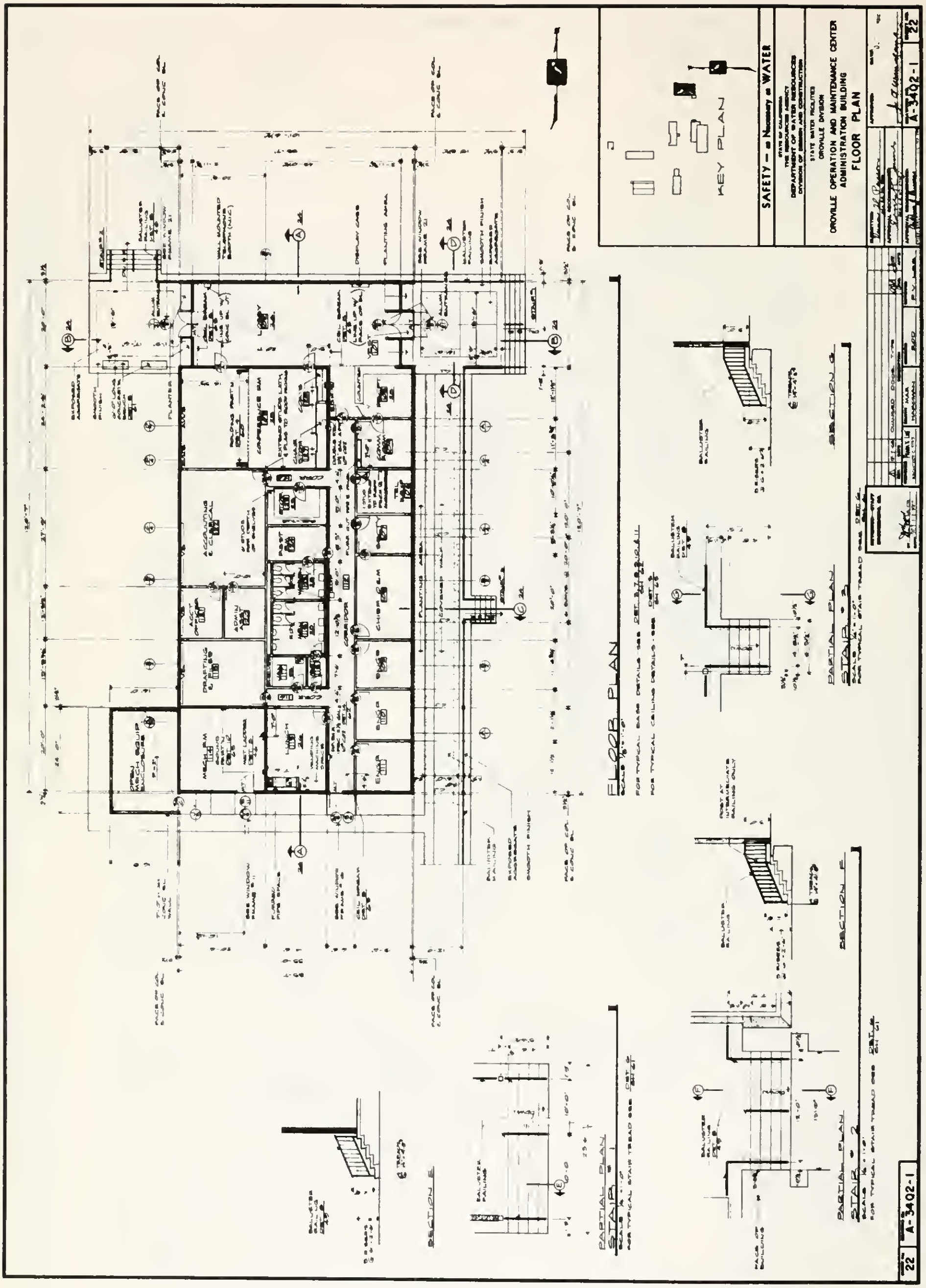

Figure 127. Oroville Operations and Maintenance Center Administration Building—Floor Plan

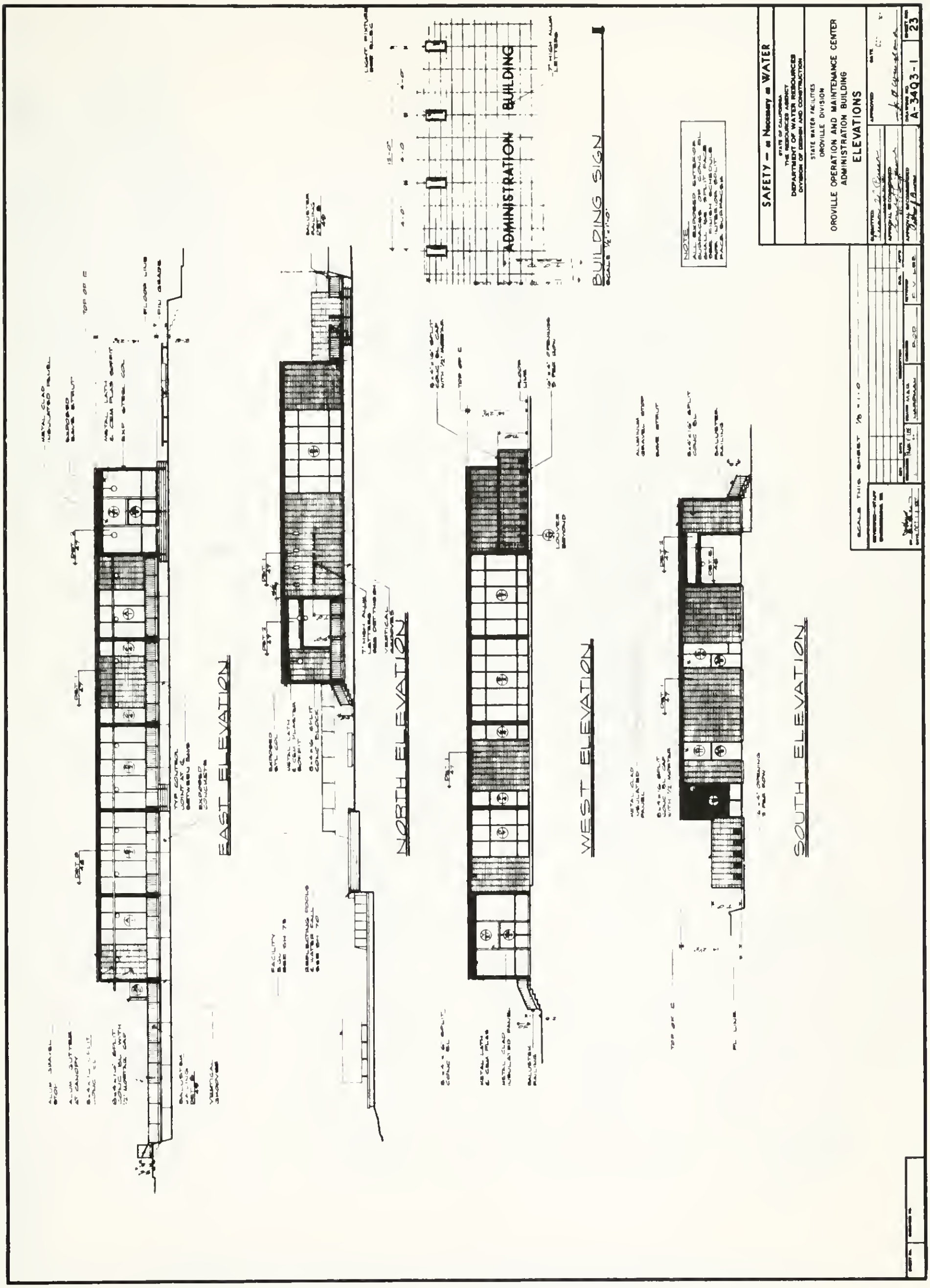

Figure 128. Oroville Operations and Maintenance Center Administration Building—Elevations

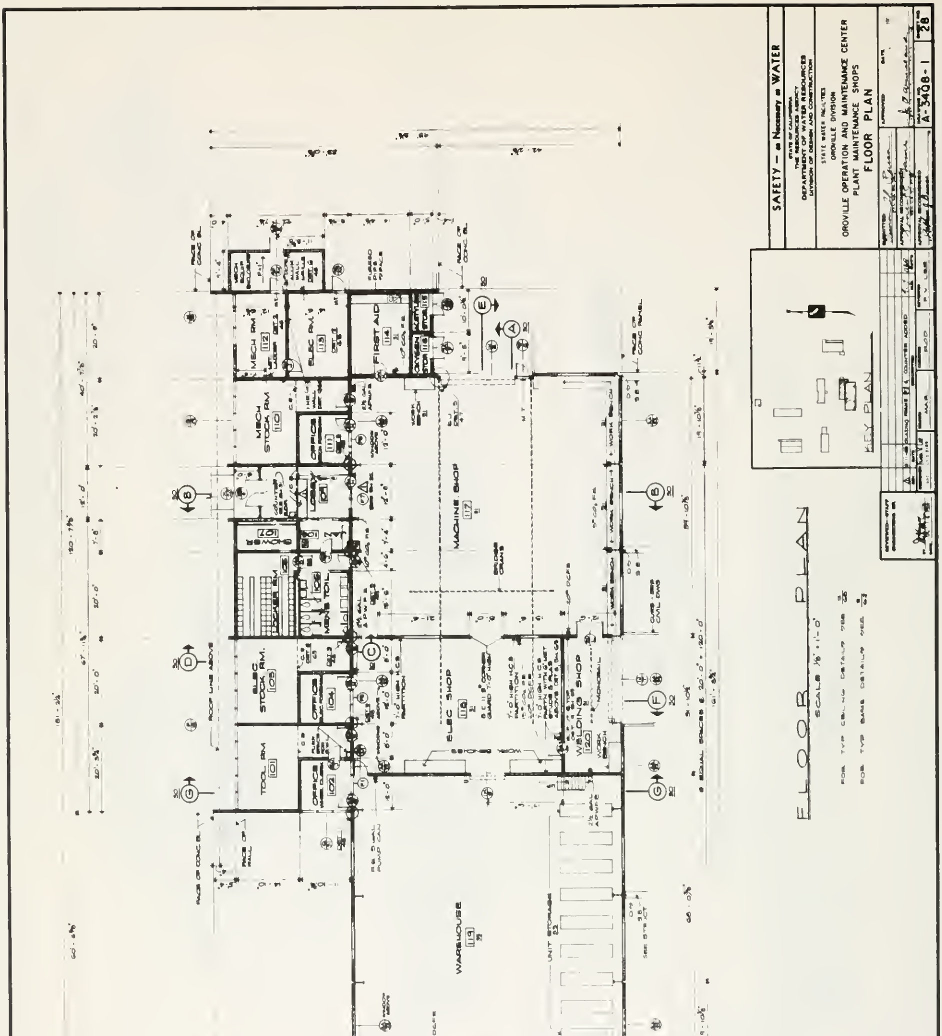

Figure 129. Oroville Operations and Maintenance Center Plant Maintenance Shops—Floor Plan

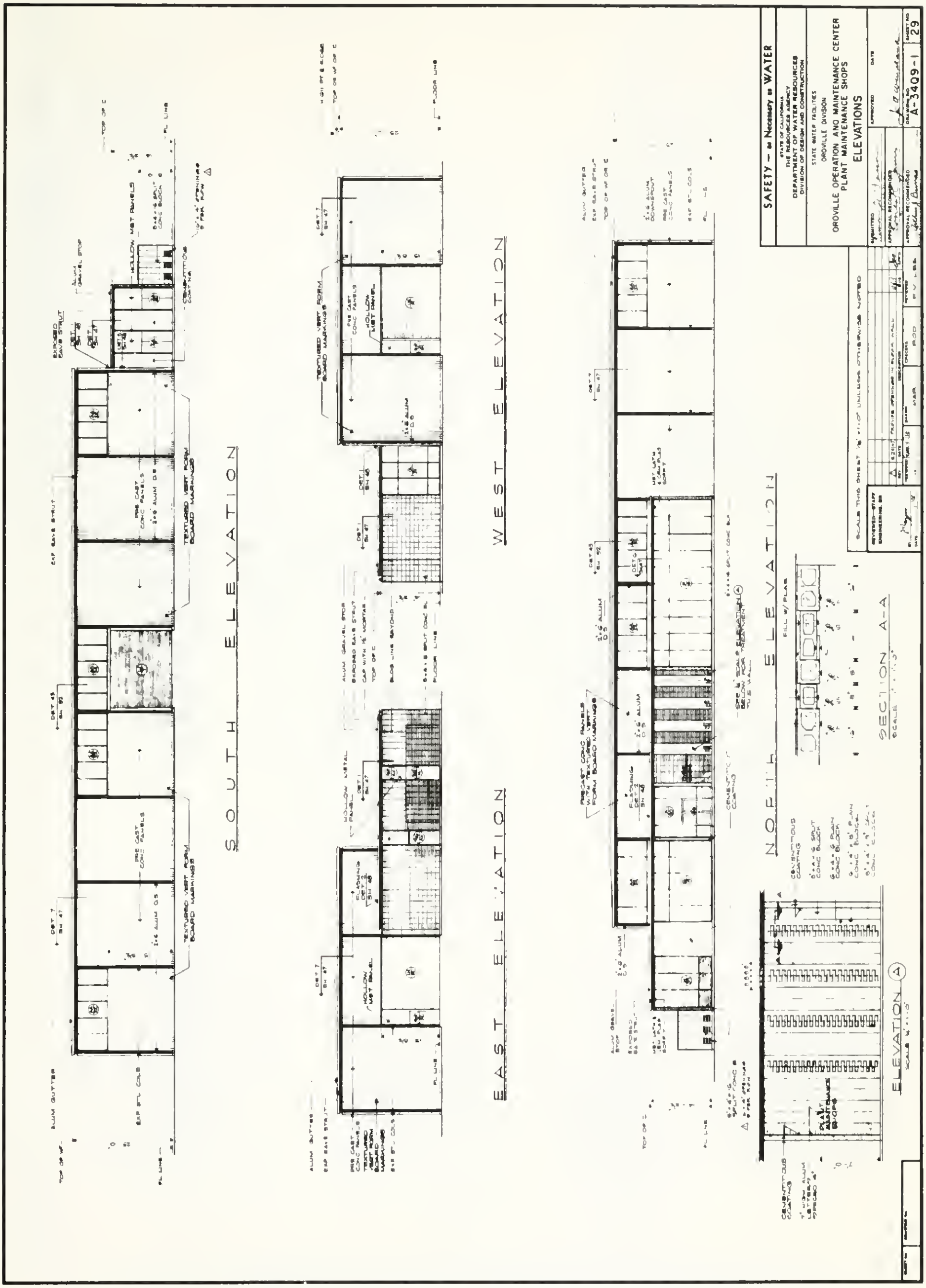

Figure 130. Oraville Operations and Maintenance Center Plant Maintenance Shops—Elevations

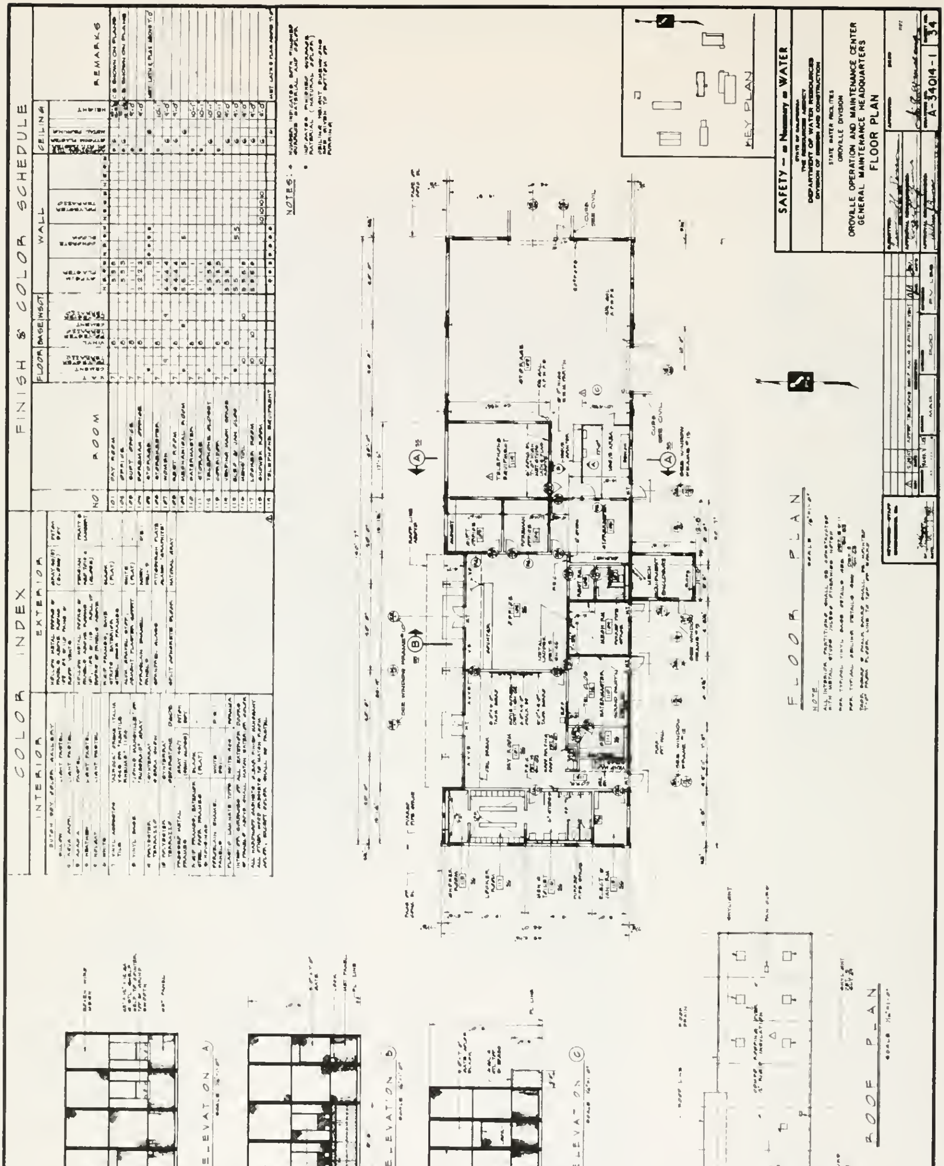

Figure 131. Oroville Operations and Maintenance Center General Maintenance Headquarters—Floor Plan

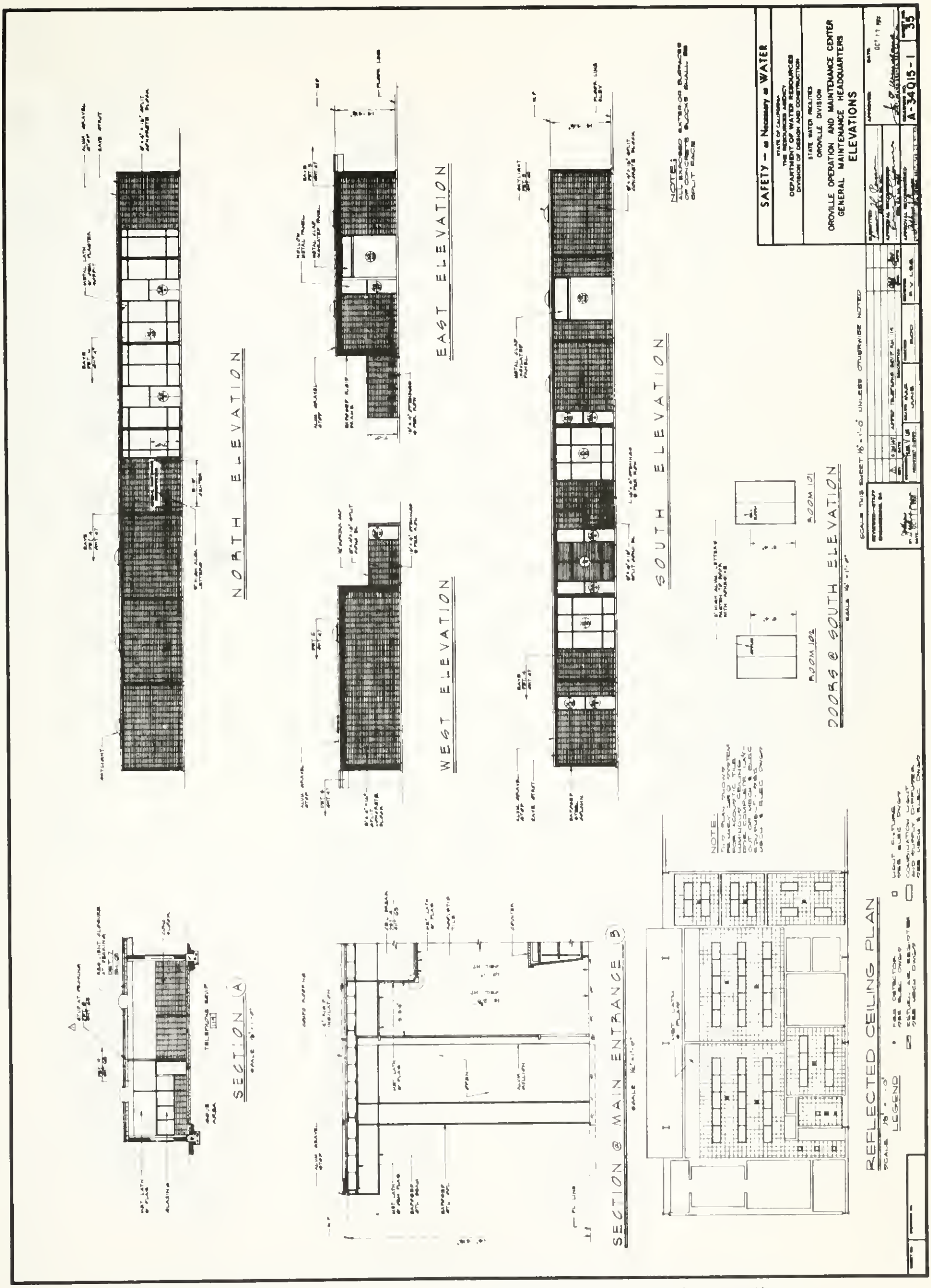

Figure 132. Oroville Operations and Maintenance Center General Maintenance Headquarters—Elevations

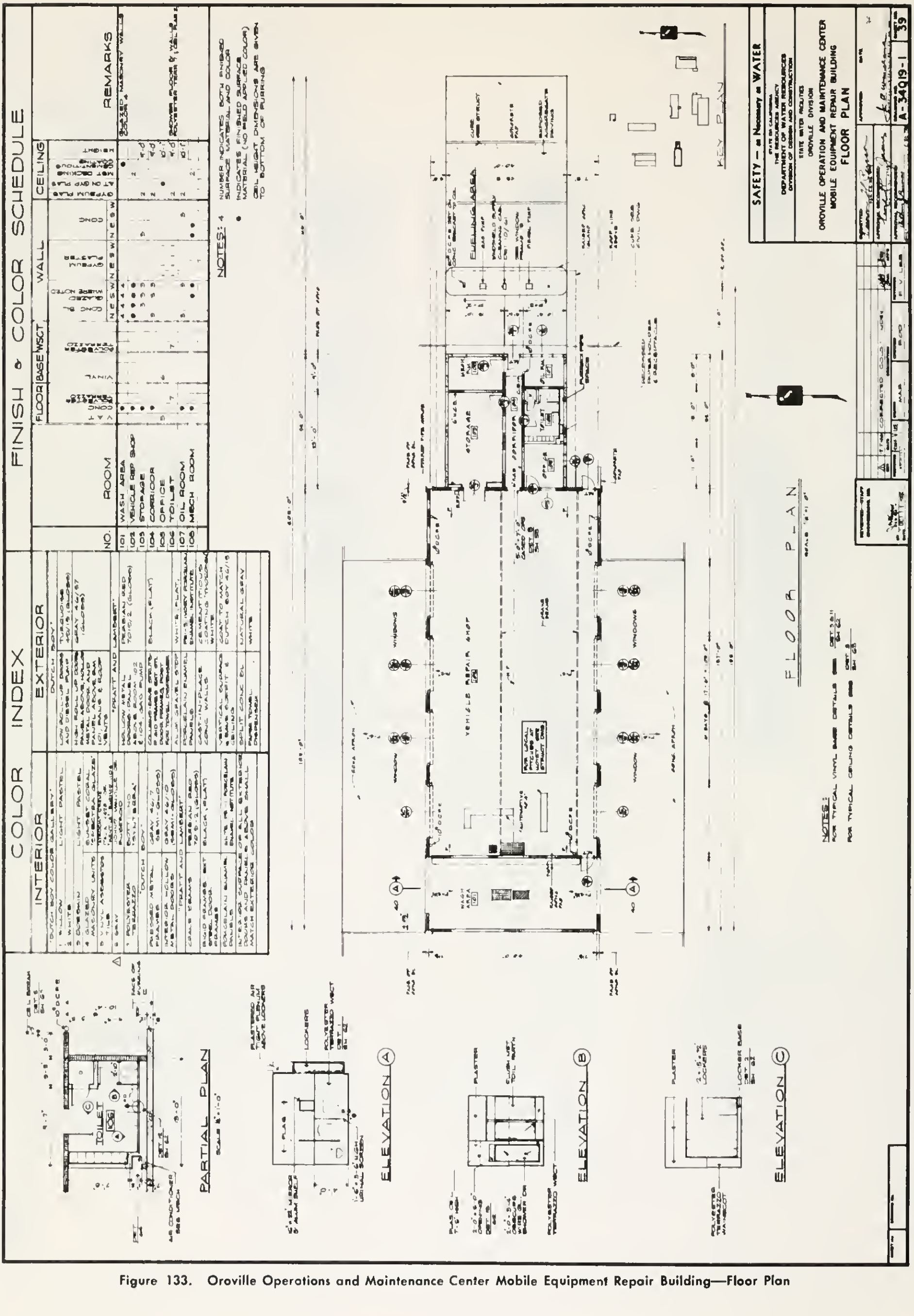

Figure 133. Oroville Operations and Maintenance Center Mobile Equipment Repair Building—Floor Plan

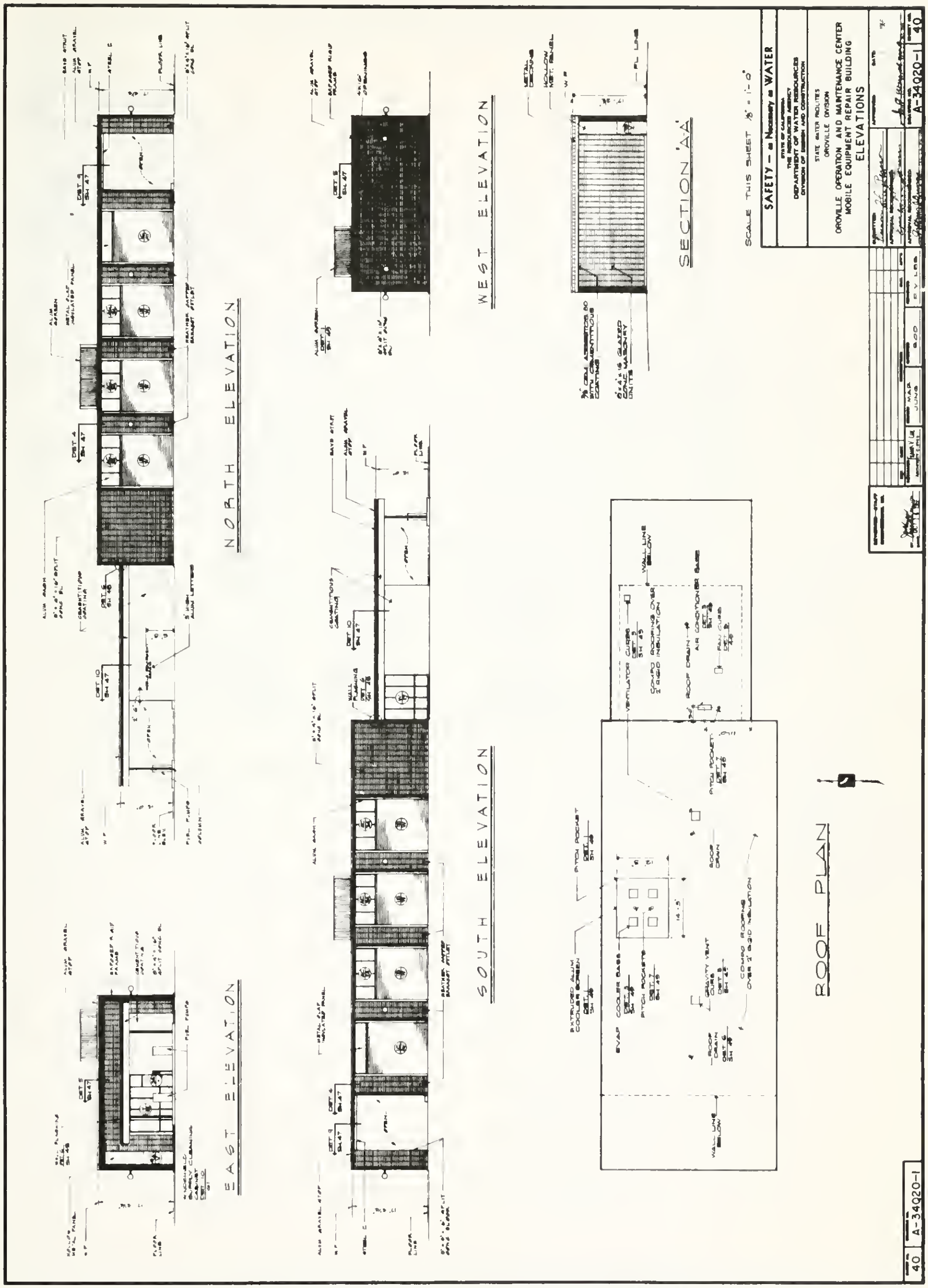

Figure 134. Oroville Operations and Maintenance Center Mobile Equipment Repair Building—Elevations

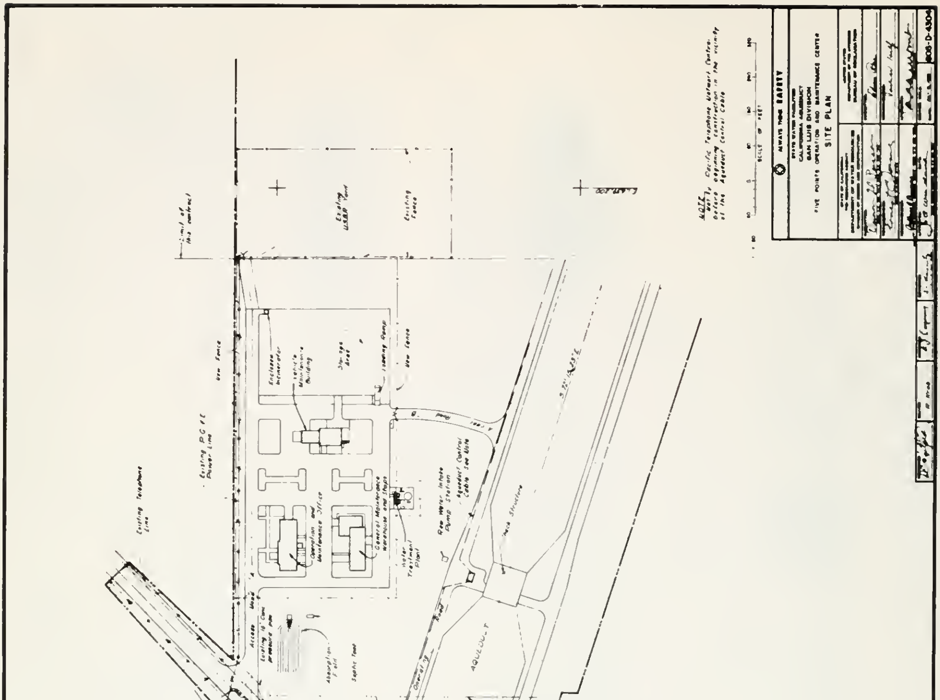

Figure 135. Five Points Operations and Maintenance Center—Site Plan

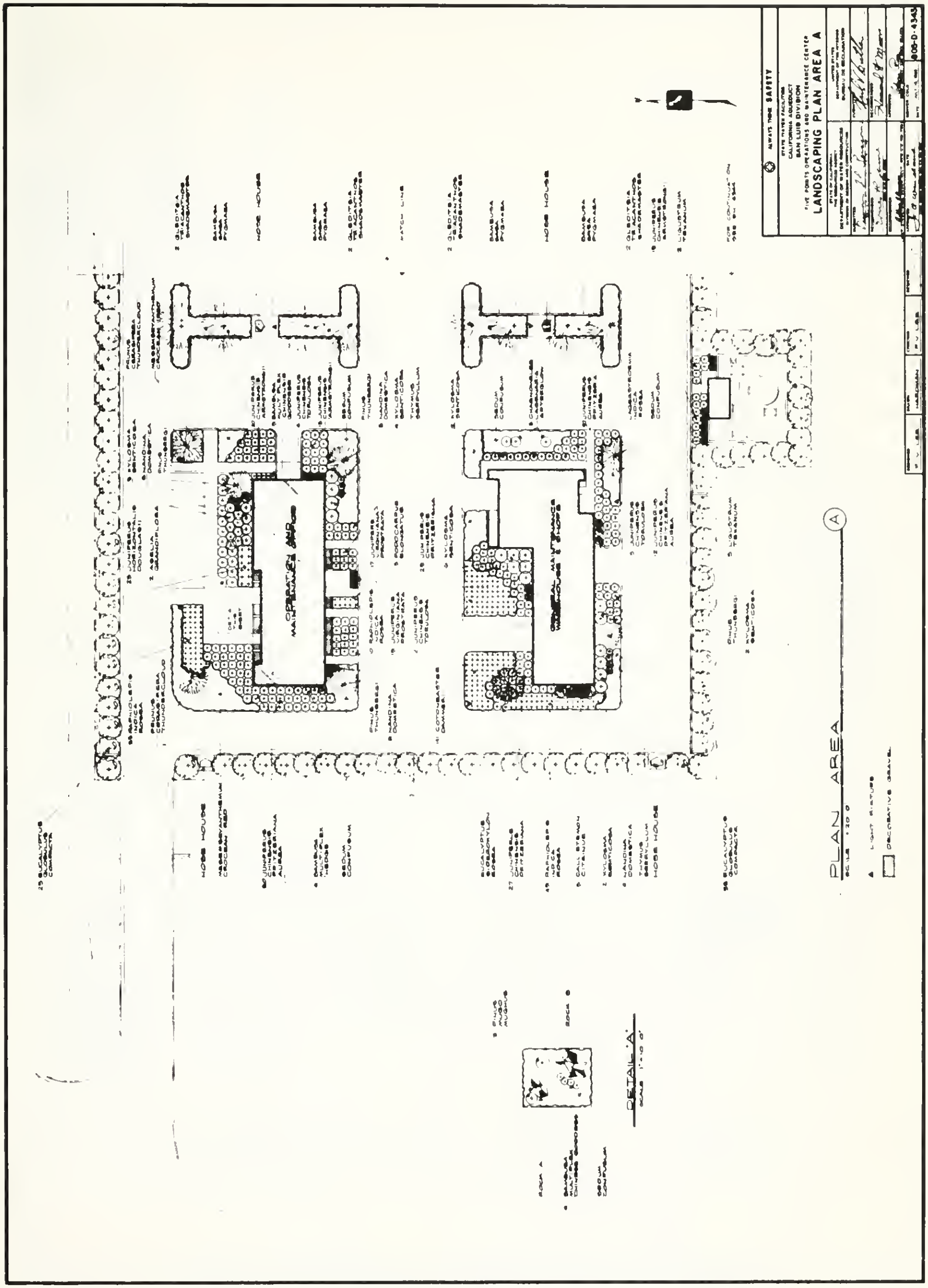

Figure 136. Five Points Operations and Maintenance Center—Landscaping Plan Area A

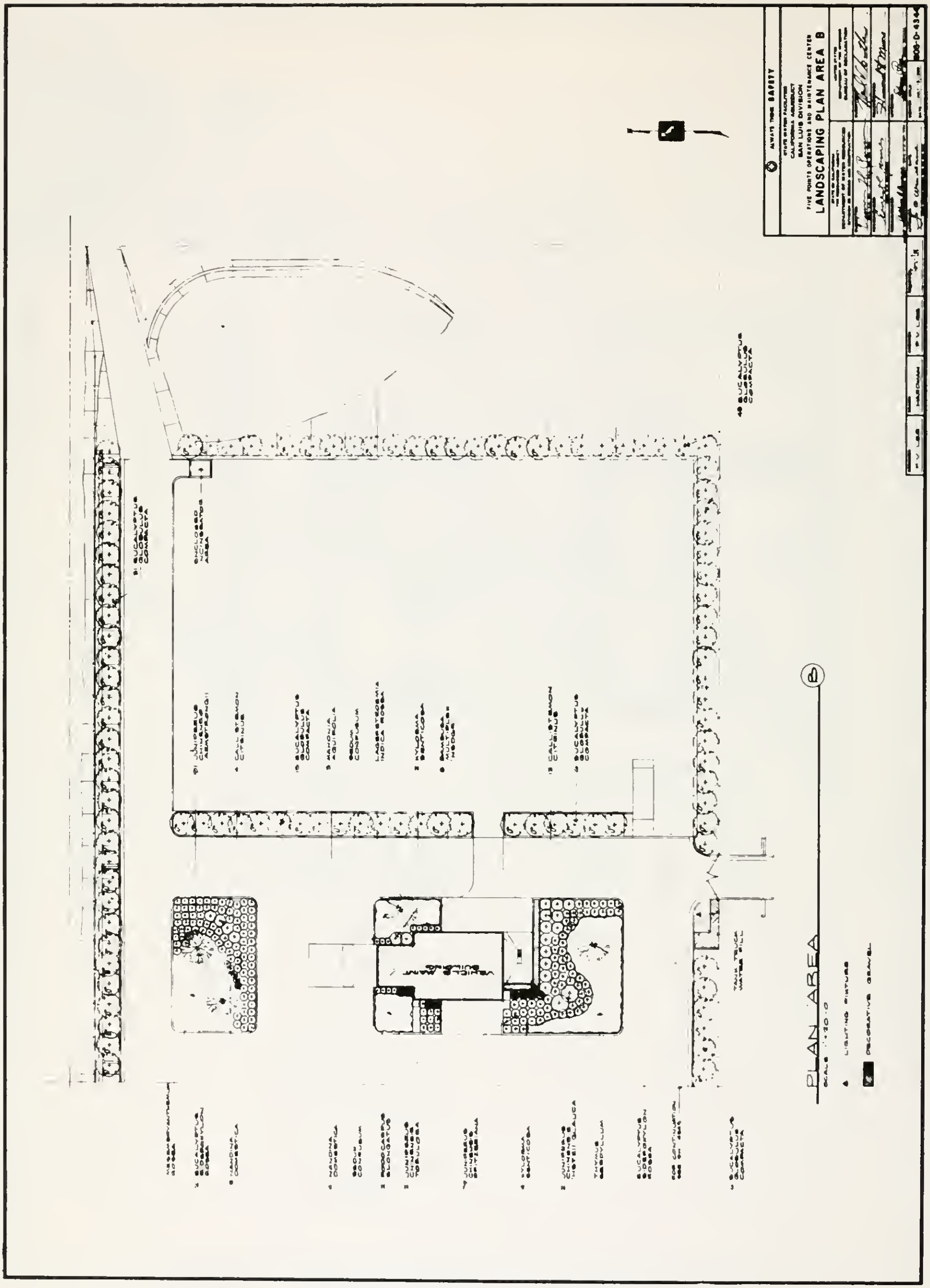

Figure 137. Five Points Operations and Maintenance Center—Landscaping Plan Area B

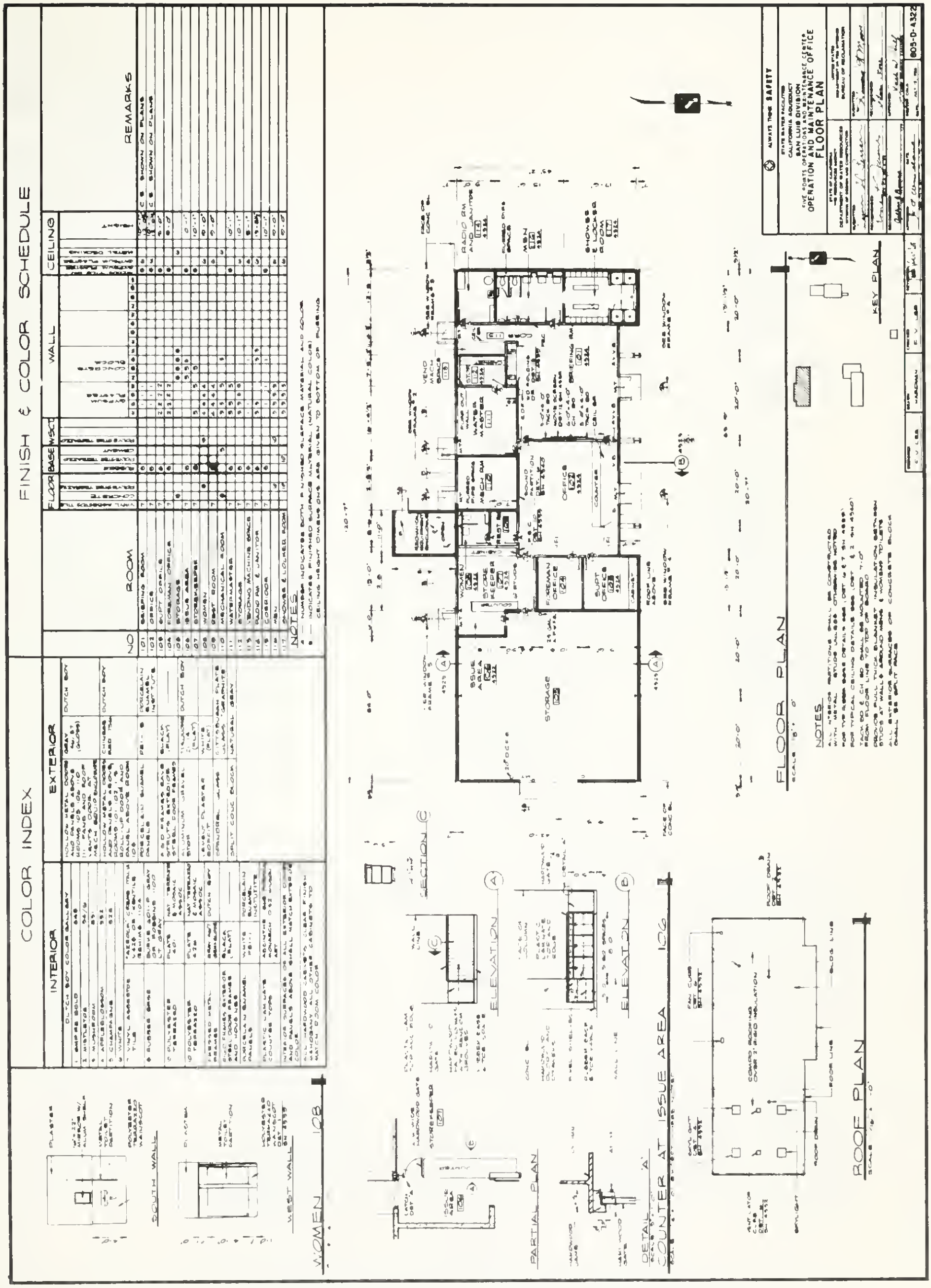

Figure 138. Five Points Operations and Maintenance Center Office—Floor Plan

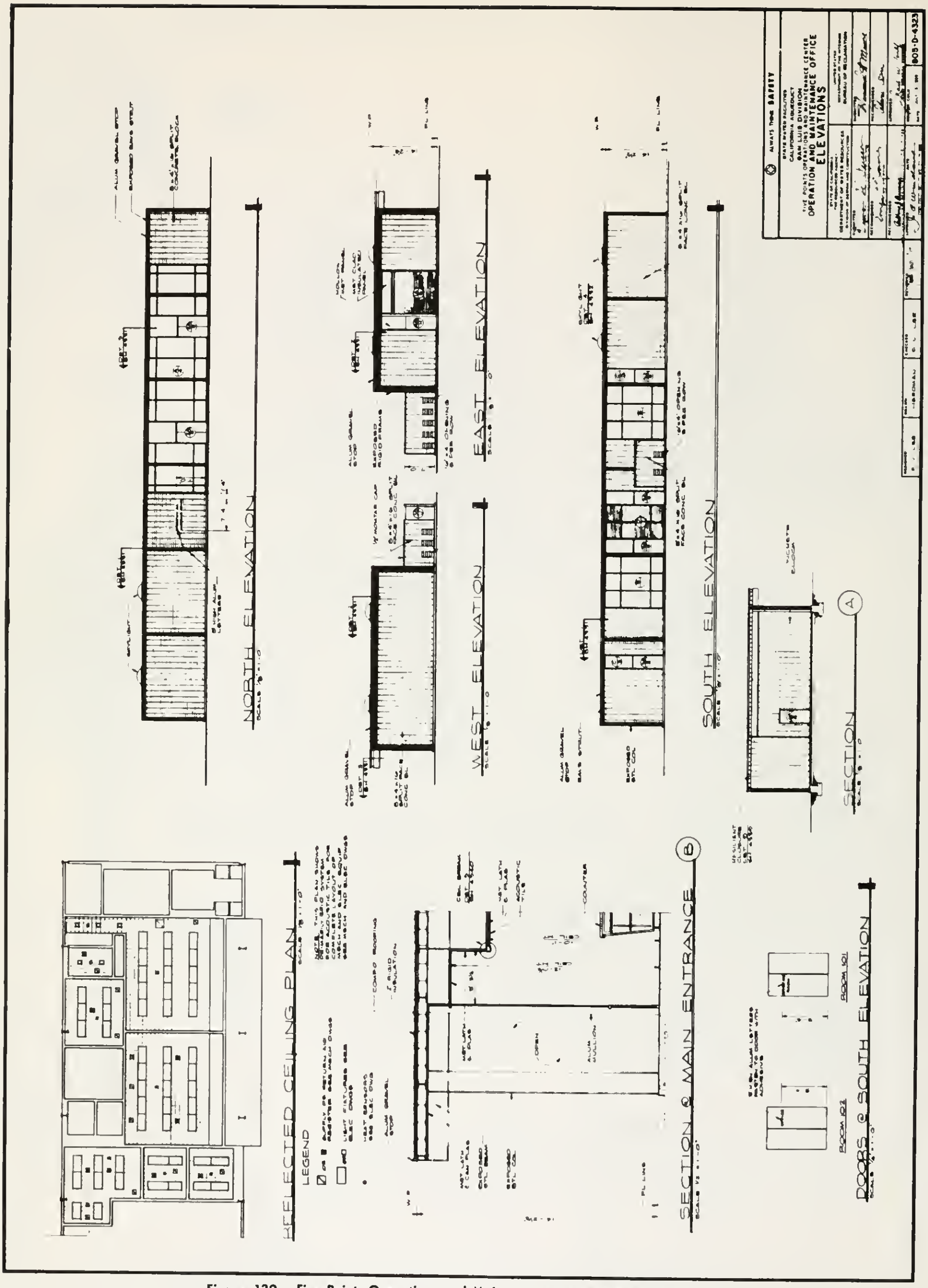

Figure 139. Five Points Operations and Maintenance Center Office—Elevations

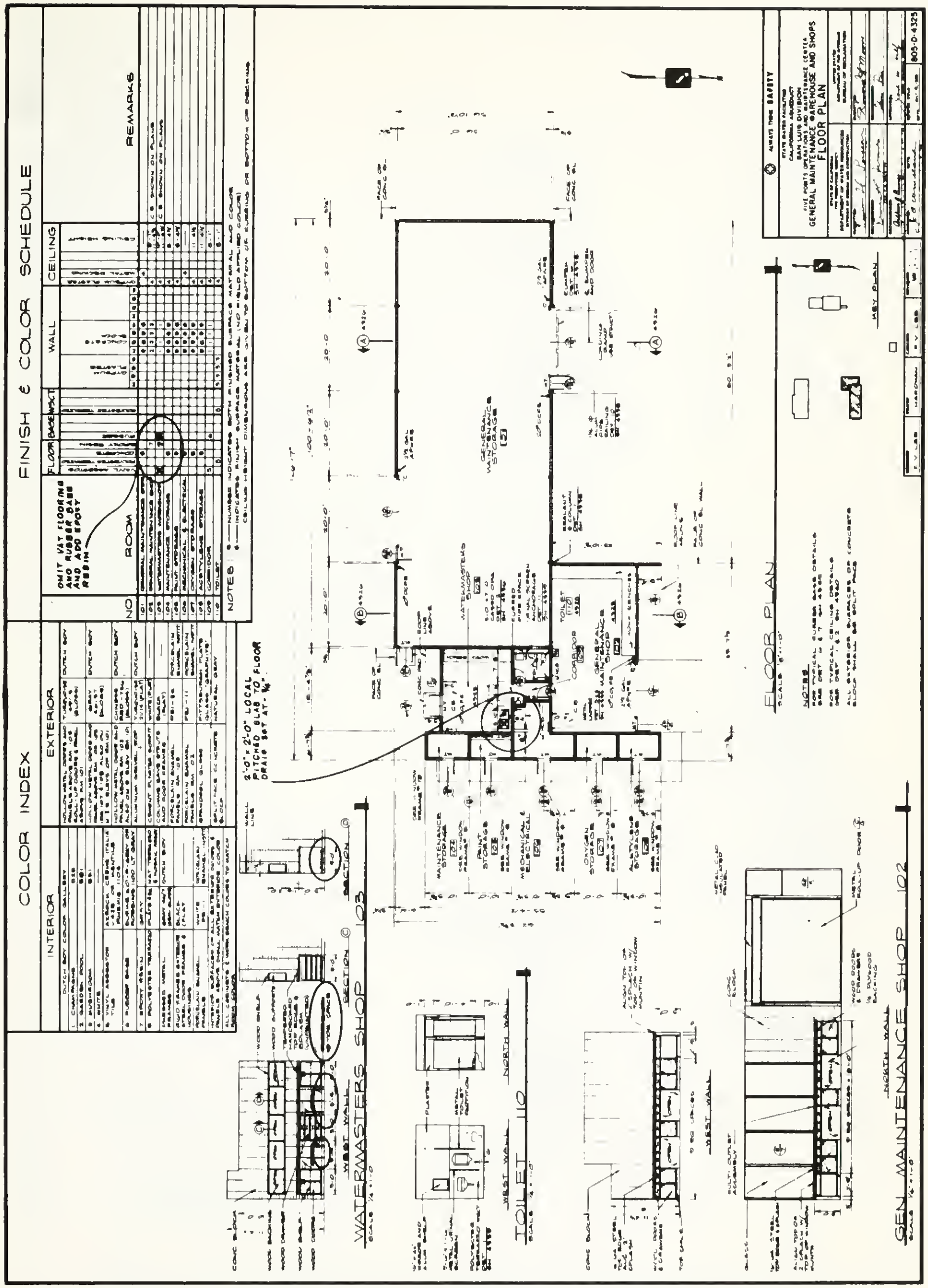

Figure 140. Five Points Operations and Maintenance Center General Maintenance Warehouse and Shops—Floor Plan

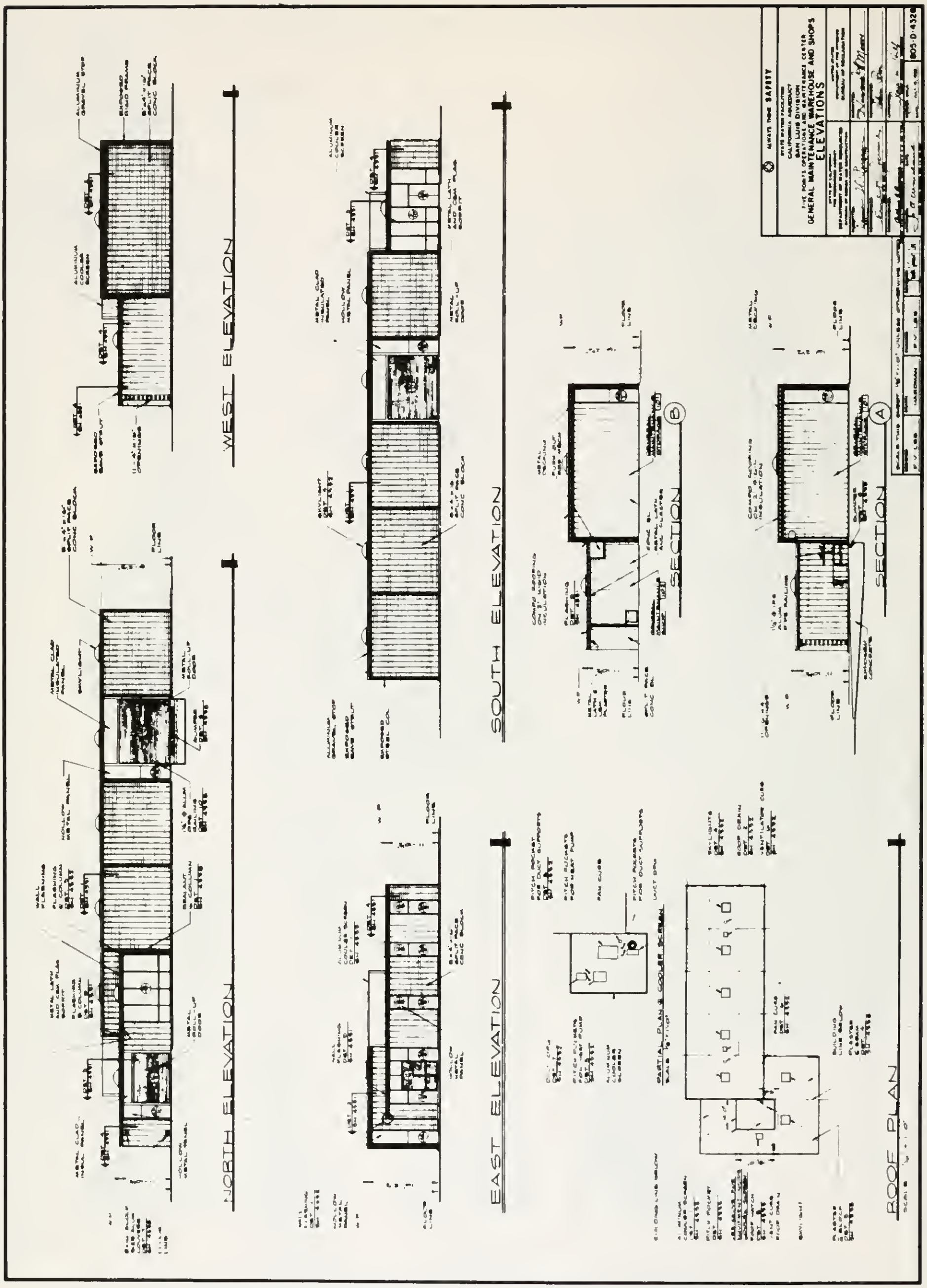

Figure 141. Five Points Operations and Maintenance Center General Maintenance Warehouse and Shops—Elevations

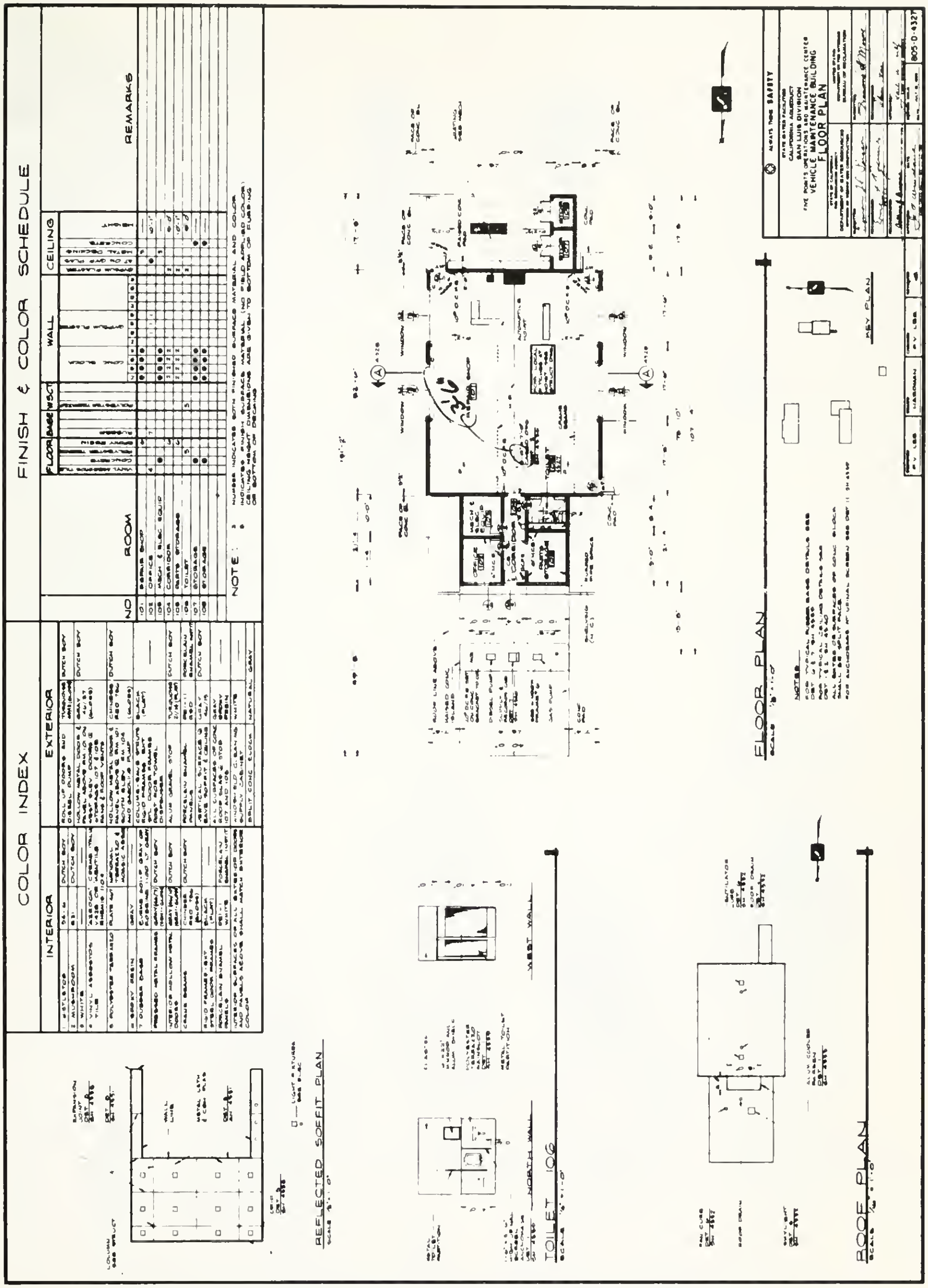

Figure 142. Five Points Operations and Maintenance Center Vehicle Maintenance Building—Floor Plan

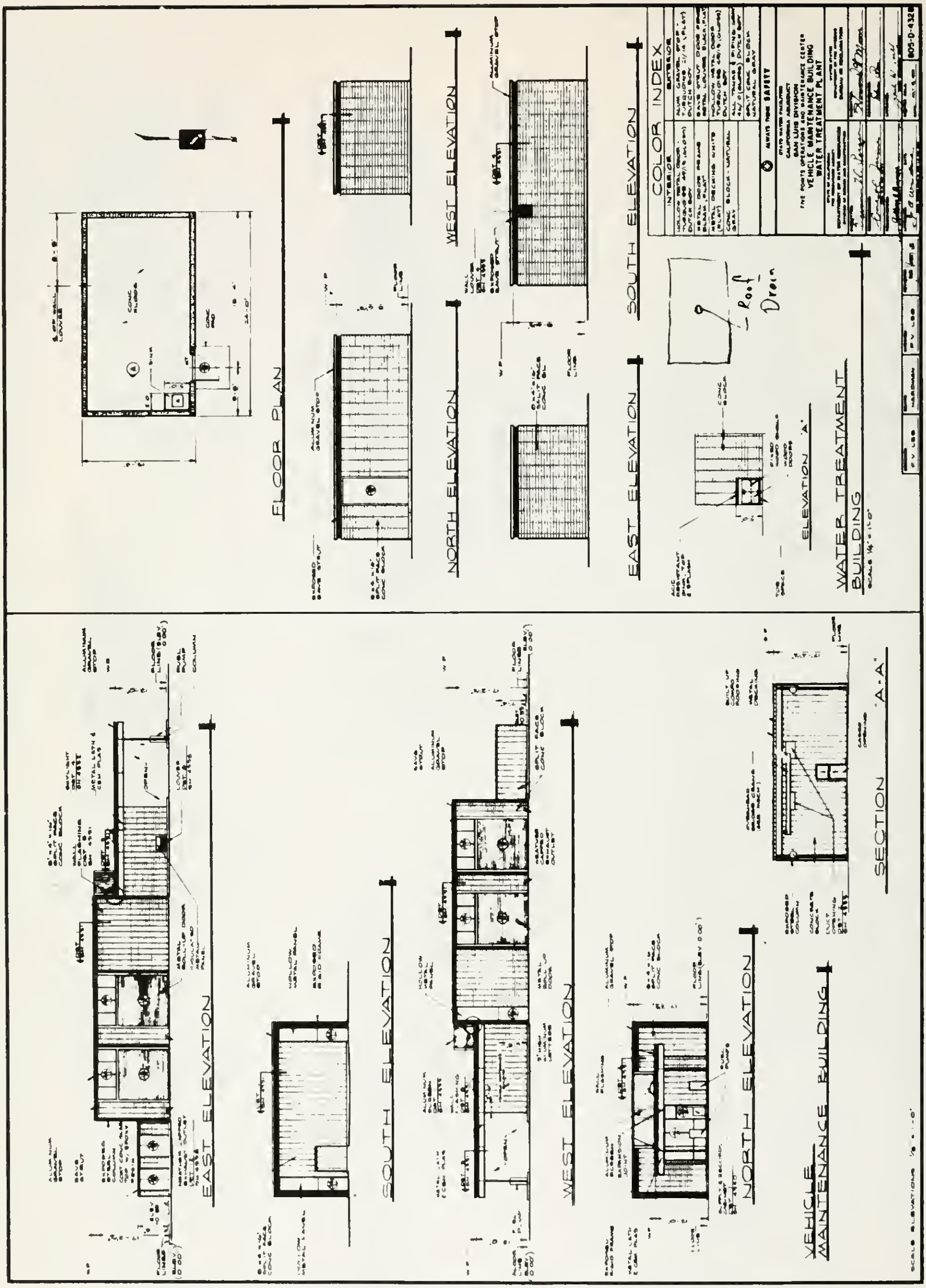

Figure 143. Five Paints Operatians and Maintenance Center Vehicle Maintenance Building—Water Treatment Plant

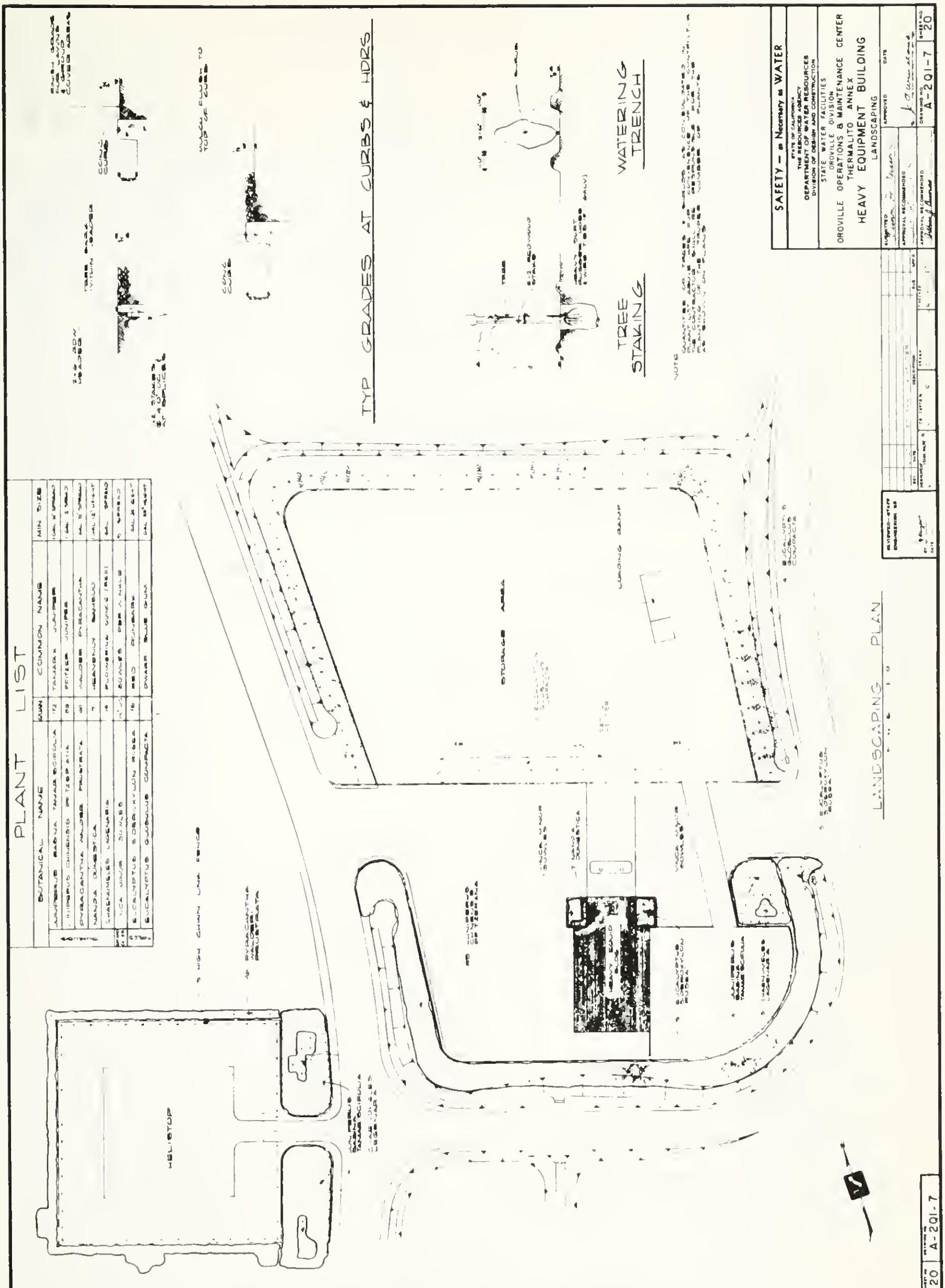

Figure 144. Thermalito Annex Heavy Equipment Building—Landscaping

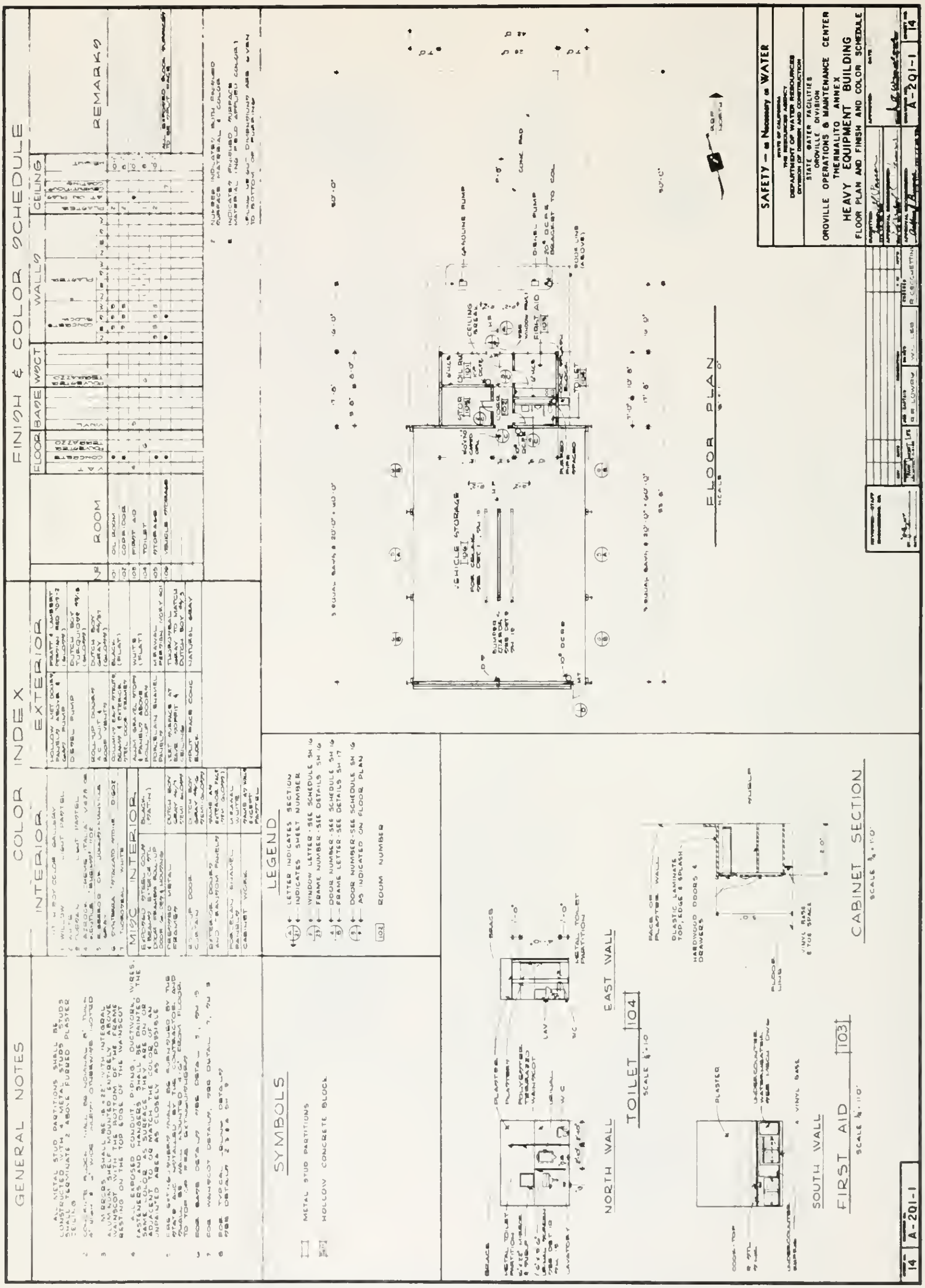

Figure 145. Thermalito Annex Heavy Equipment Building—Floor Plan

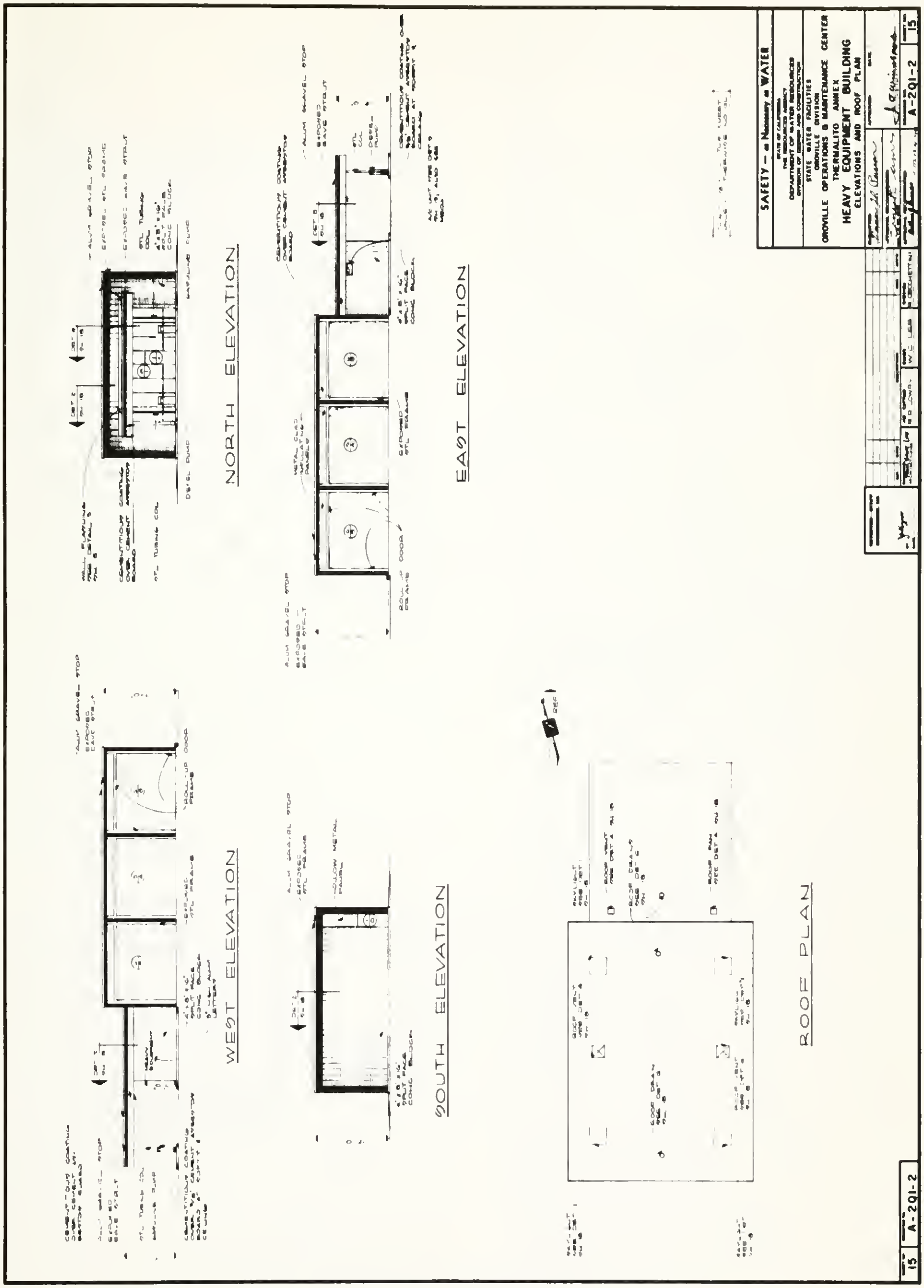

Figure 146. Thermalito Annex Heavy Equipment Building—Elevations and Roof Plan

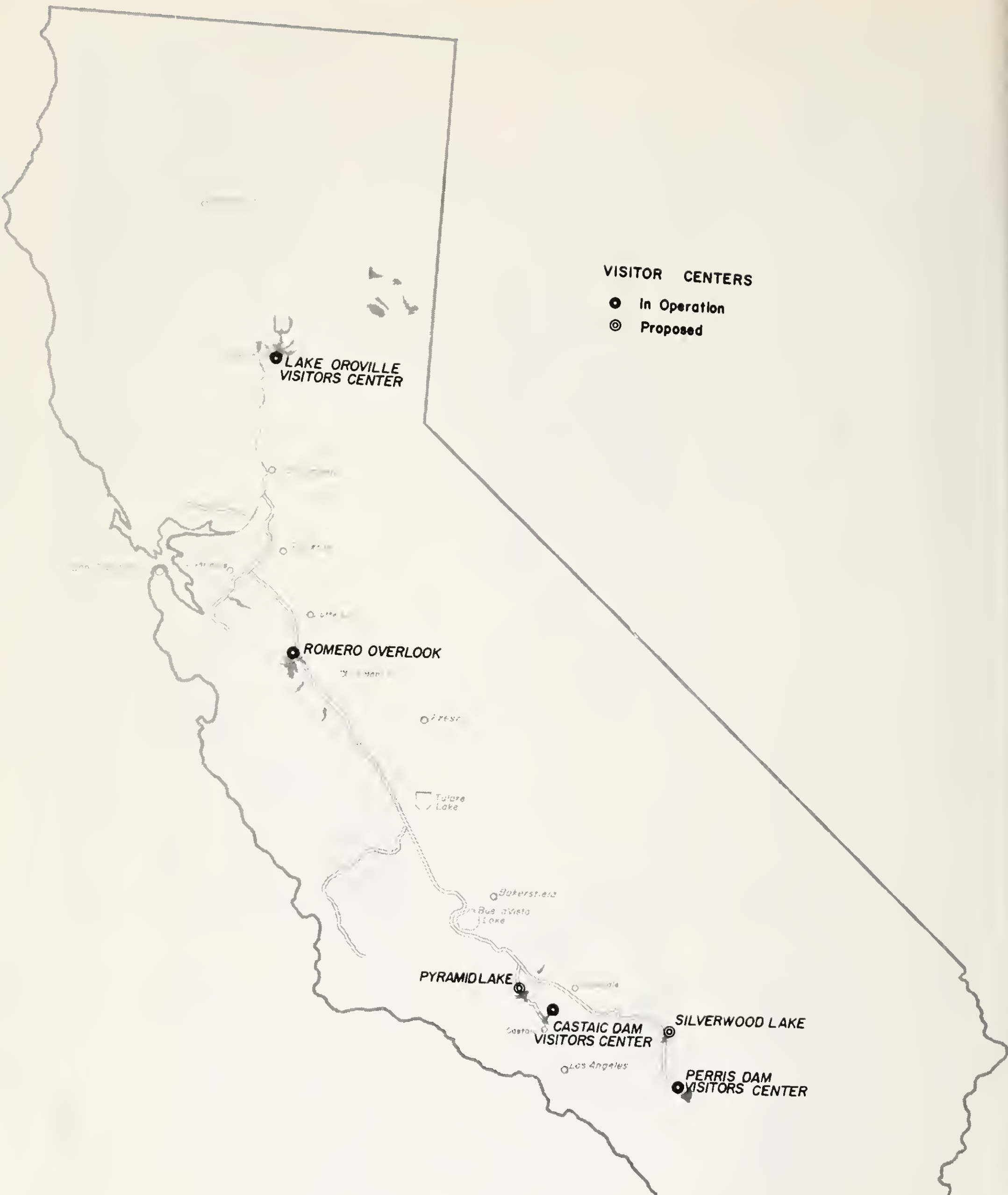

Figure 147. Location Map—Visitor Centers

CHAPTER IX. VISITOR CENTERS

Introduction

The Department of Water Resources provides visitor facilities at appropriate works of the State Water Project, both during and following construction. The purpose of these facilities is to provide information about the Project to the public, provide a convenient location where the public can best view the Project, and channel visitors in a safe and orderly manner.

Visitor centers are being built and maintained by the Department at various points of interest throughout the Project. They are located considering magnitude of the facility, access, and public interest (Figure 147).

Lake Oroville Visitors Center located at Kelly Ridge, overlooking Oroville Dam and Lake Oroville, and Romero Overlook located on a promontory above the north shore of San Luis Reservoir are completed and open to the public. Centers overlooking Perris Dam and Lake Perris and Castaic Dam and Lake are under construction and will be opened to the public early in 1975. Plans are being formulated for visitor centers at Silverwood Lake and at Pyramid Lake. All centers are open most of the day, seven days a week.

Visitor services also are maintained at several facilities along the Project to accommodate special interest groups. Reservations can be made for guided tours through these facilities. Included are the Operations Control Center and the underground Edward Hyatt Powerplant at Oroville Dam; the Feather River Fish Hatchery at Oroville; the Delta Pumping Plant at Byron; the Pumping-Generating Plant at San Luis Reservoir; the A. D. Edmonston Pumping Plant, the major lift at the south end of the San Joaquin Valley; and the Devil Canyon Powerplant just north of the City of San Bernardino.

Lake Oroville Visitors Center

Lake Oroville Visitors Center is located just east of Oroville Dam and high above the Lake on Kelly Ridge (Figures 148 and 149). This vantage point provides a commanding view of the Dam, Bidwell Bar Bridge, and the various arms of the Lake itself. Visitors may enjoy the view from an observation platform which also serves as a survey tower for project triangulation checks (Figure 150).

The building was designed to contrast with its setting and constructed with natural redwood (Figures 151, 152, and 153). This structure is shared with, and operated and maintained by, the Department of Parks and Recreation.

Audio-visual aids and fixed displays in the Center's exhibit area tell the story of the State Water Project and the history of the Oroville area. Several motion picture films are shown to visitors; one tells the construction story of Oroville Dam and another the story of the State Water Project. The Department of Parks and Recreation has exhibits pertaining to its activities.

Photo slide sequences augmenting the fixed visual displays can be started by visitors. Both types depict various uses of water, conservation of stored water in project reservoirs, and flood control benefits provided by project dams.

Lake Oroville Visitors Center has a concessionaire-operated snack bar and a small shop that sells souvenirs and items of local interest.

Romero Overlook

Romero Overlook is a visitors center for the State-Federal joint-use facilities and is located at San Luis Dam and Reservoir (Figures 154 and 155). The visitors building and related site development occupy a high promontory slightly north of the Dam on the edge of the lake. This site gives a beautiful panoramic view of the lake and project features and is easily accessible from State Highway 152, the Pacheco Pass Road.

The building exterior is done in redwood and natural wood tones supplemented by a deep gray-colored metal roof. It was designed and constructed by the Department in cooperation with the U. S. Bureau of Reclamation (Figures 156 and 157).

The building interior was designed to receive visitors in a reception area having walls and floors decorated in warm colors which blend with natural wood beams and ceilings. Glass viewing areas on the lake side of the building allow visitors to view the area while being protected from almost constant winds.

The exhibit portion of the building has several areas of interest which visitors may tour by themselves or with assistance of a guide. One of these areas is devoted to the story of uniting State Water Project and Federal Central Valley Project facilities to bring water to the San Luis region. It shows how both projects transport water to and store water in San Luis Reservoir during periods of surplus and release this water during high irrigation water demand periods. In another area of the building, a color television film portrays dam and reservoir construction. Exhibit areas utilized by the Bureau include a multimedia slide show on their role in the Central Valley water program. Audio-visual displays are augmented with fixed graphic and photographic displays distributed throughout the building. For visitor comfort, one small wing of the building just off the reception area is used for a rest area complete with snack-vending machines and low-volume seating.

Grounds around the building are landscaped with plantings and rocks. Several pedestal-mounted plaques of historical and local interest are integrated with the walkways and observation deck to complete the exterior plan. A viewing telescope is provided to aid the visitors in bringing distant features into view. The telescope is used especially during seasons when waterfowl migrate to San Luis Reservoir.

Castaic Dam Visitors Center

Castaic Dam Visitors Center, under construction, will be open to the public in early 1975. The building site is located on a high bluff just east of Castaic Dam and provides an encompassing view of the entire Castaic area (Figures 158 and 159). The Dam and Lake are prominent in the westerly quadrant of view. Just downstream from the Dam, Castaic Lagoon is clearly visible.

Castaic Lake, one of four major reservoirs formed by State Water Project dams south of the Tehachapi Mountains, provides water for The Metropolitan Water District of Southern California and others. The Lake provides water-oriented recreation for the millions of residents of the greater Los Angeles Basin. Boat ramps, picnic areas, and rest areas are complete on the east and west side of the Lake. Los Angeles County is currently building additional facilities around Castaic Lagoon. Los Angeles County Parks Department operates all state- and county-funded recreation facilities at Castaic Lake and Lagoon.

The Visitors Center is of unique design utilizing an octagon as the basic geometric shape (Figures 160 and 161). The exterior is natural redwood, glass, and textured concrete with a deep gray-colored metal roof. Landscaping around the building provides a pleasing transition from native vegetation to the building complex.

The State Water Project story is told using audiovisual and graphic displays. Importance of the role played by Castaic Dam, Lake, and delivery facilities is stressed. Full-height glassed windows provide a protected comfortable place for visitors to view the onsite physical features during windy and inclement weather. On more pleasant days, an outside walkway at the building's perimeter affords an excellent view of the surrounding area.

A vending area is provided to the east of the Center below the building and main parking lot. This area is near the bus parking area and is complete with picnic tables and shade structures. Here, visitors may rest and enjoy their refreshments and the mild climate of the high chaparral country.

Perris Dam Visitors Center

Perris Dam and Lake Perris, at the southern terminus of the California Aqueduct, is located near the community of Perris in Riverside County just off U. S. Highway 395. At this location, the State delivers water to The Metropolitan Water District of Southern California for further distribution as far south as San Diego, some 80 miles away. The Lake provides, as an added benefit, fresh-water recreation to Southern Californians.

The Dam and Lake are the only visible features of the State Water Project for many miles. Water is conveyed to the Lake underground through the 27-mile-long Santa Ana Valley Pipeline, which begins north of San Bernardino at the Devil Canyon Powerplant Afterbay. Perris Dam and Lake Perris is heavily visited by local residents and vacationers from other areas and was therefore selected as the site of a major project visitors center. The Department of Parks and Recreation is constructing a major complex of onshore recreation facilities around the Lake.

The building and related site development are located just north of the Dam on a high rock outcropping which affords a panoramic view of the Dam, Lake, Alessandro Island, beach recreation features, and Perris Valley downstream from the Dam (Figure 162). The center is now under construction (1974) and will be completed and open to the public in early 1975.

One design objective for the center was to disturb as little of the natural setting at the site perimeter as possible. This was achieved in the natural rock setting by using larger outcroppings for the building foundation and leaving individual rocks around foundation walls undisturbed. The building design is concentrated around the hexagon and partial hexagon as the basic geometric shapes (Figures 163 and 164). The exterior is natural redwood, textured concrete, glass, glazed asbestos trimmed in redwood, and brick veneer with a deep gray-colored metal roof. Landscaping at the building entrance complements the design as does the natural rock and vegetation.

The building interior is devoted to telling the State Water Project story and importance of Perris Dam and Lake Perris on local water supplies and recreation. The central wing of the building has an audiovisual room which utilizes films and slides to inform visitors about the Project. There also is a glassed observation area from which a good view of the Dam and Lake is obtained. The west wing has rest facilities, and the east wing is furnished with fixed displays in graphic and photographic form. The end room in the east wing is a hexagon, and the display supports and furniture also utilize this geometric shape.

The grounds outside the building were left as natural as possible. It is in this setting below and east of the main building that a vending area complete with picnic tables is provided. This area affords visitors a place to rest and have refreshments while enjoying a commanding view of the Lake and recreation area. Access paths are provided for the hearty who wish to ascend the higher rock-covered hills west of the site.

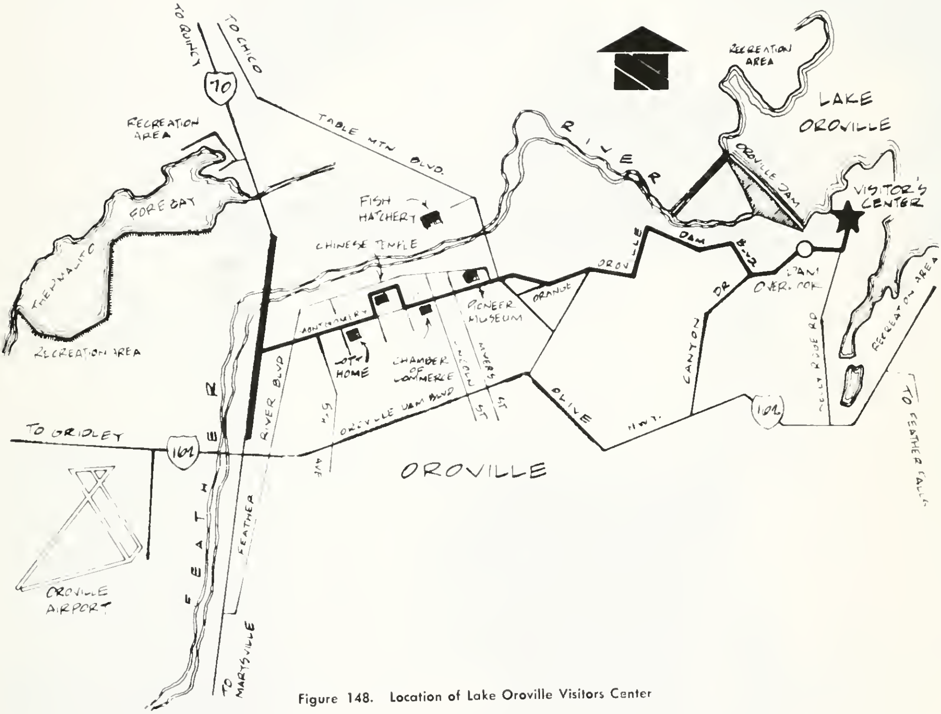

Figure 148. Location of Lake Oroville Visitors Center

Figure 149. Lake Oroville Visitors Center

Figure 150. Lake Oroville Visitors Center—Observation Tower

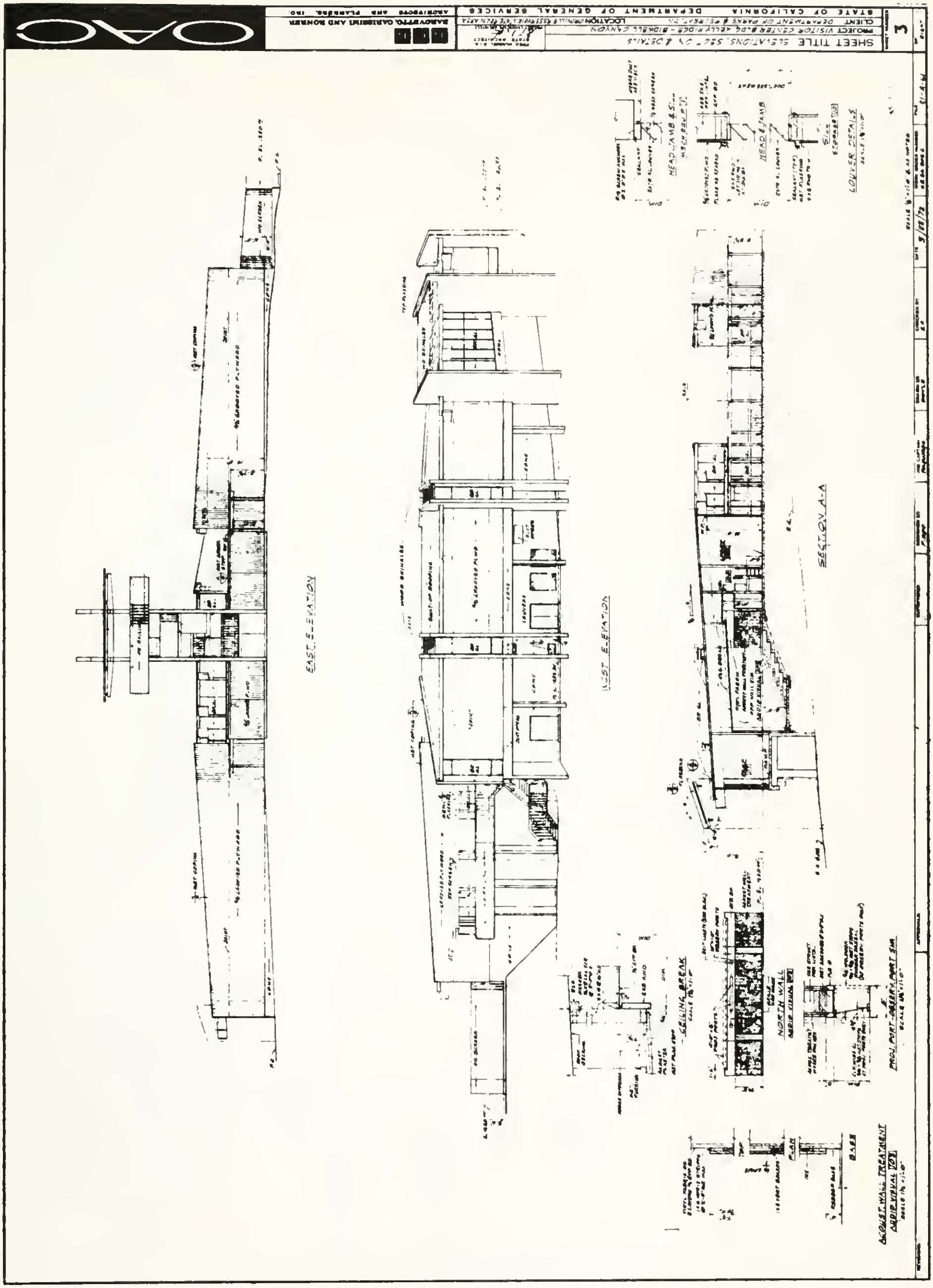

Figure 151. Lake Oroville Visitors Center—Elevations

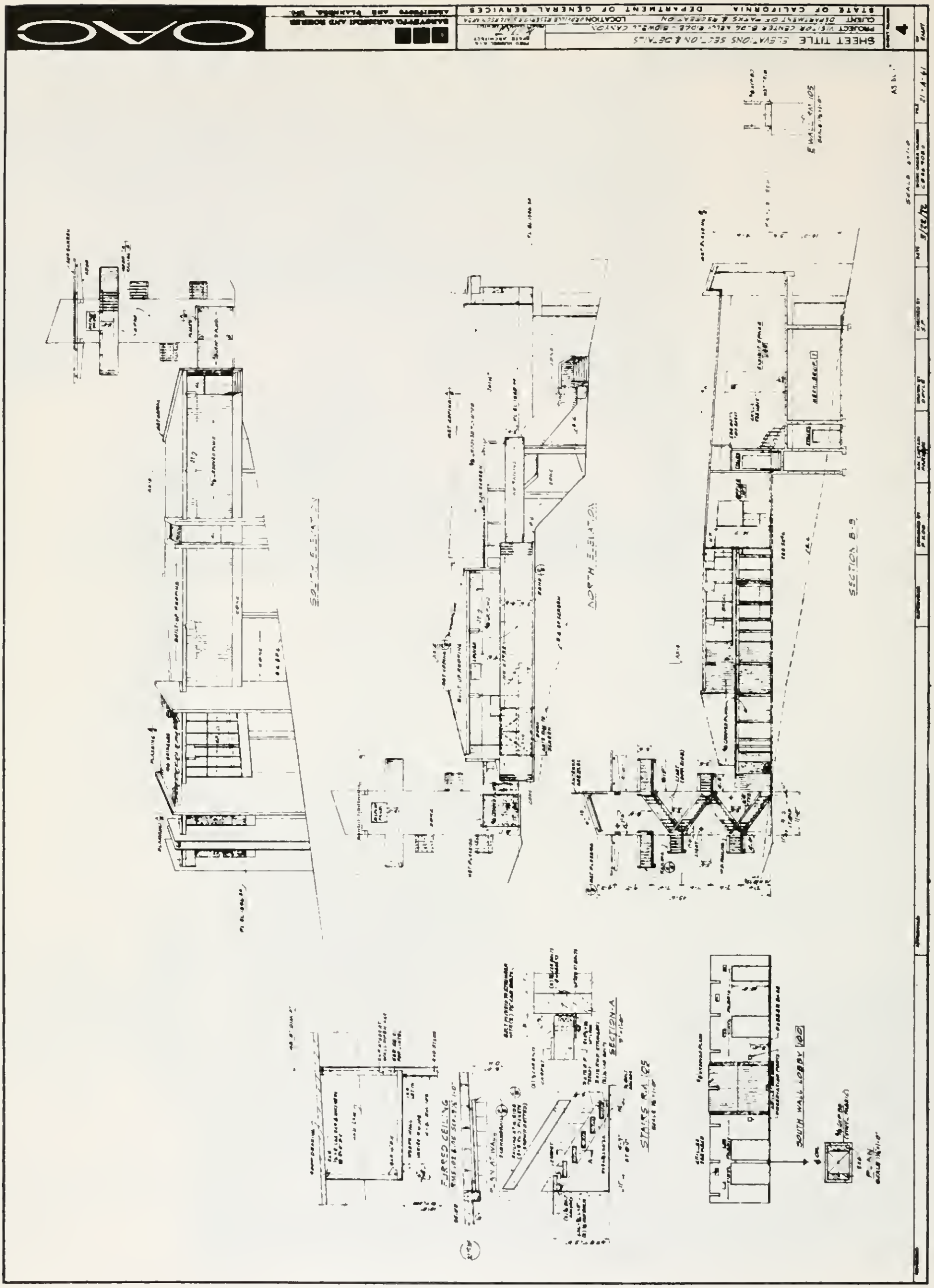

Figure 152. Lake Oroville Visitors Center—Sections

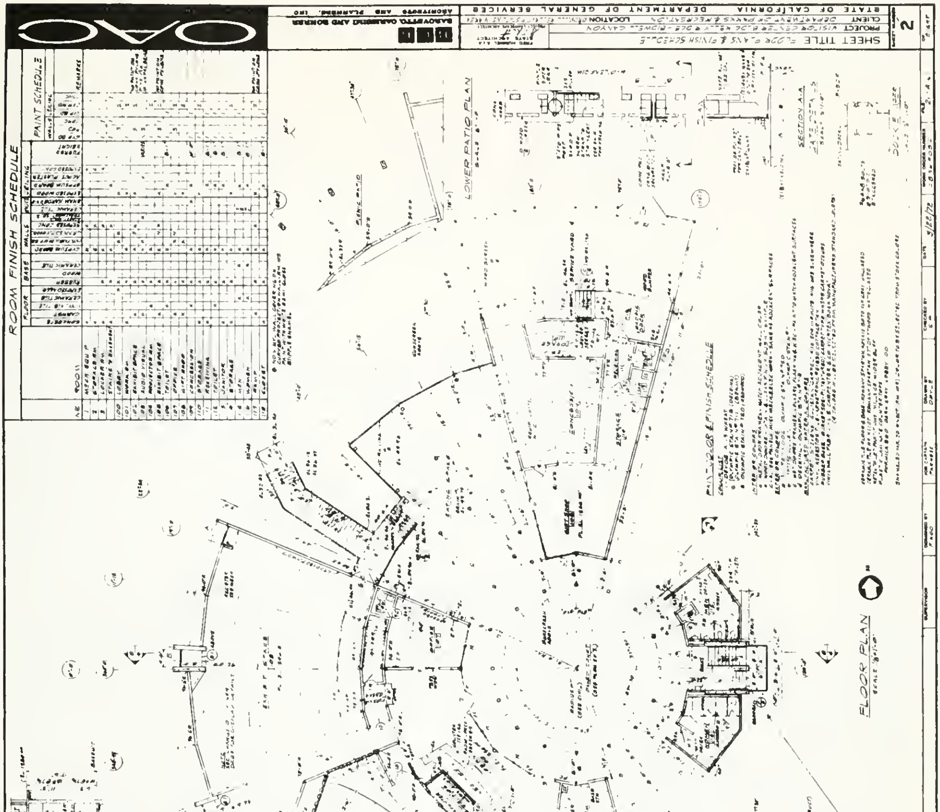

Figure 153. Lake Oroville Visitors Center—Floor Plan

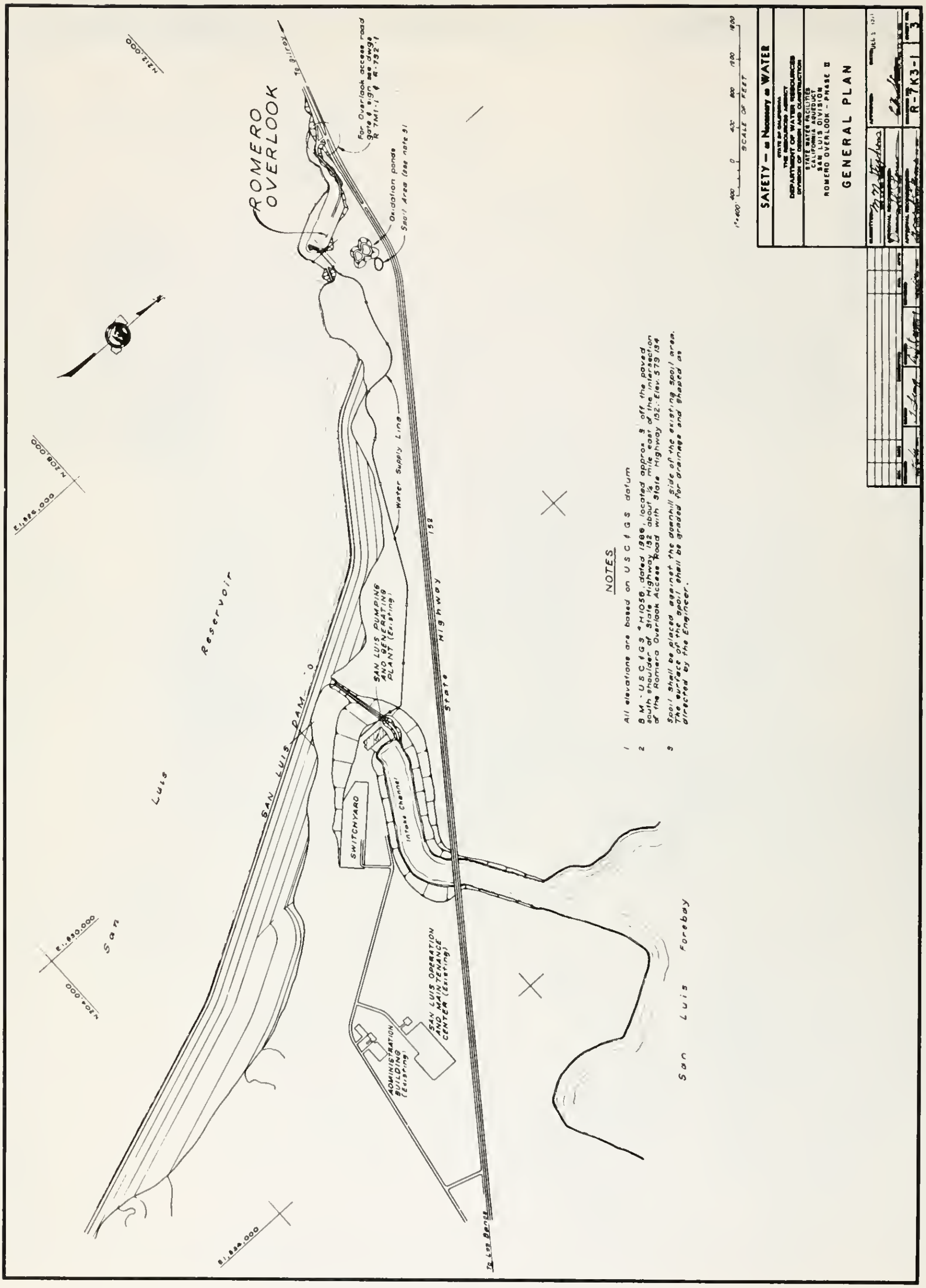

Figure 154. Location of Romero Overlook

Figure 155. Romero Overlook

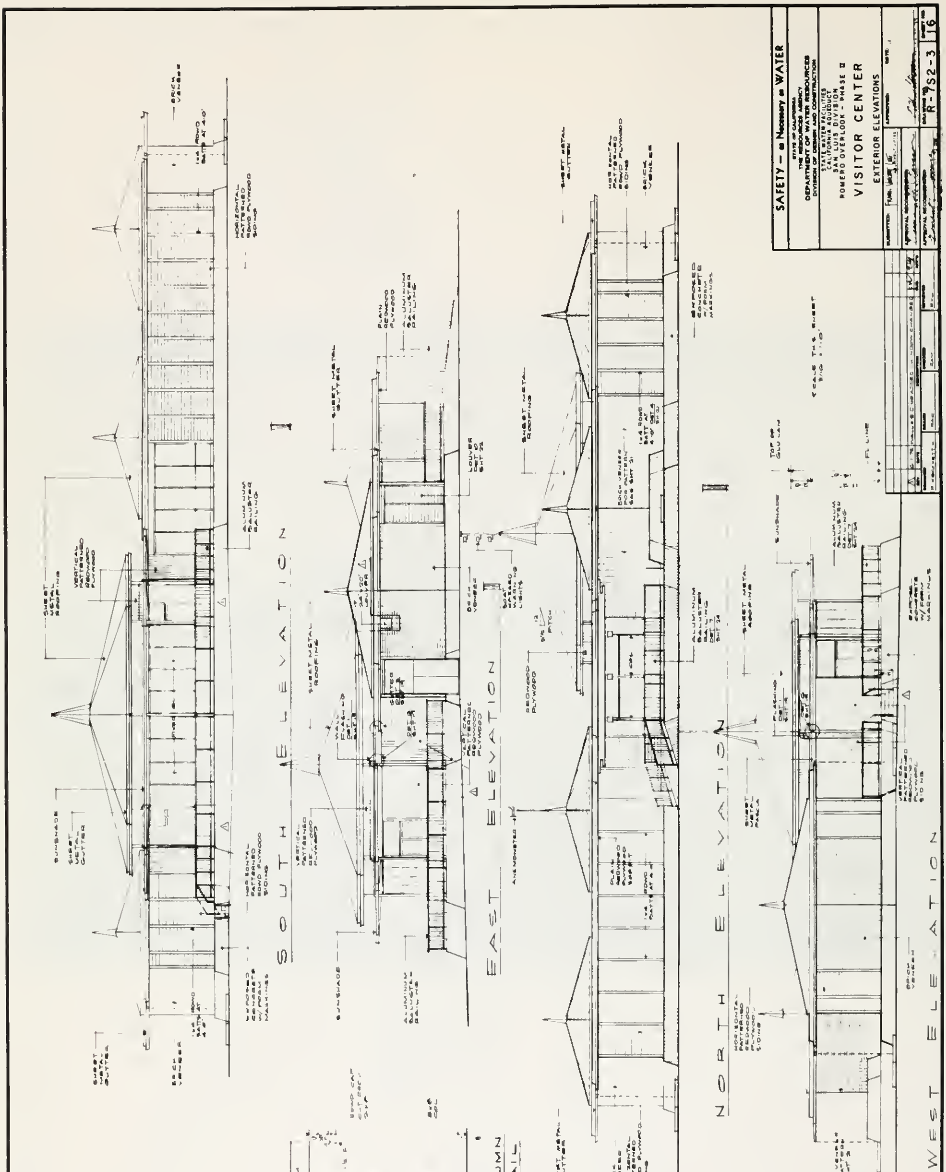

Figure 156. Romero Overlook—Elevations

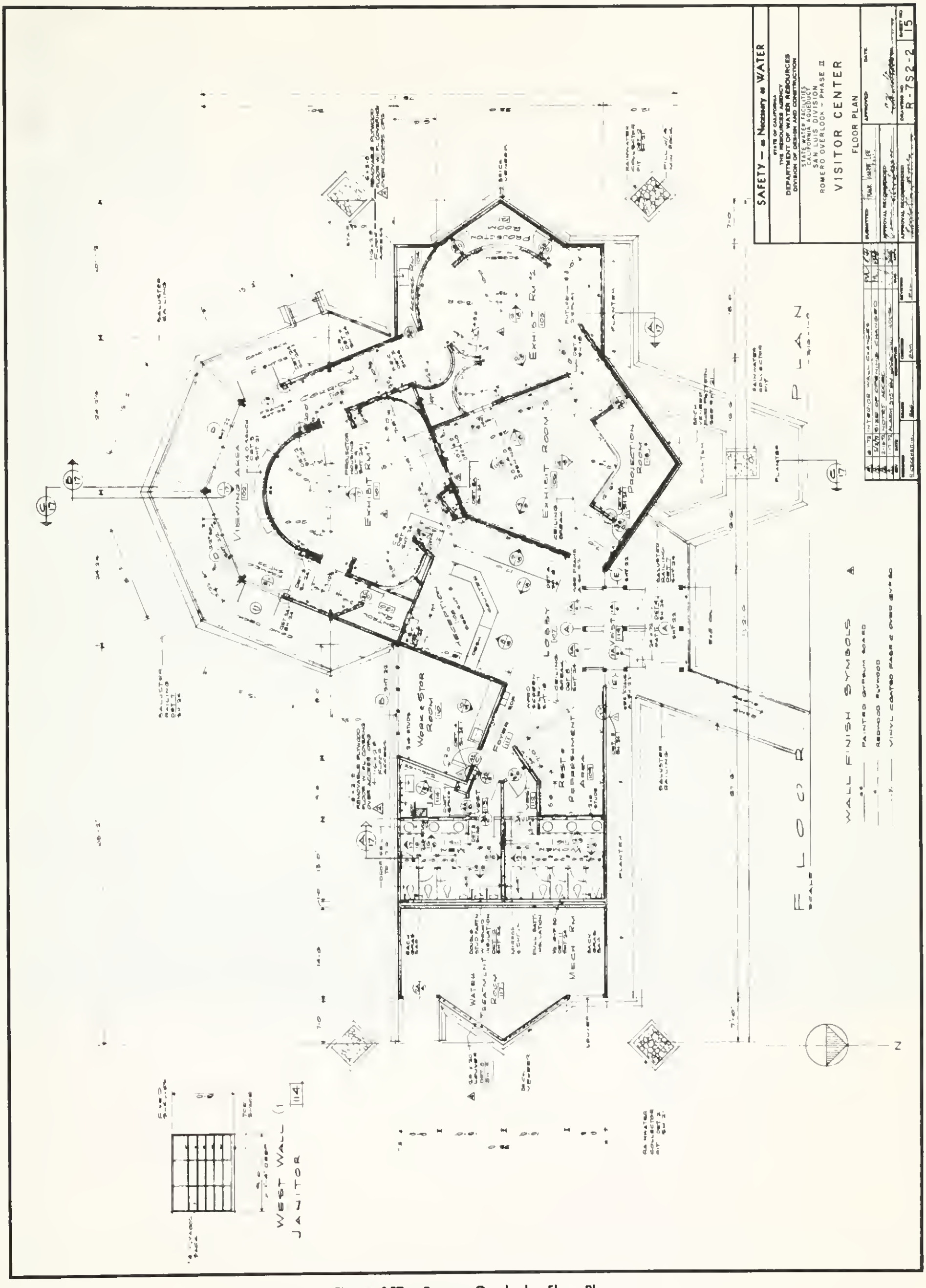

Figure 157. Romero Overlook—Floor Plan

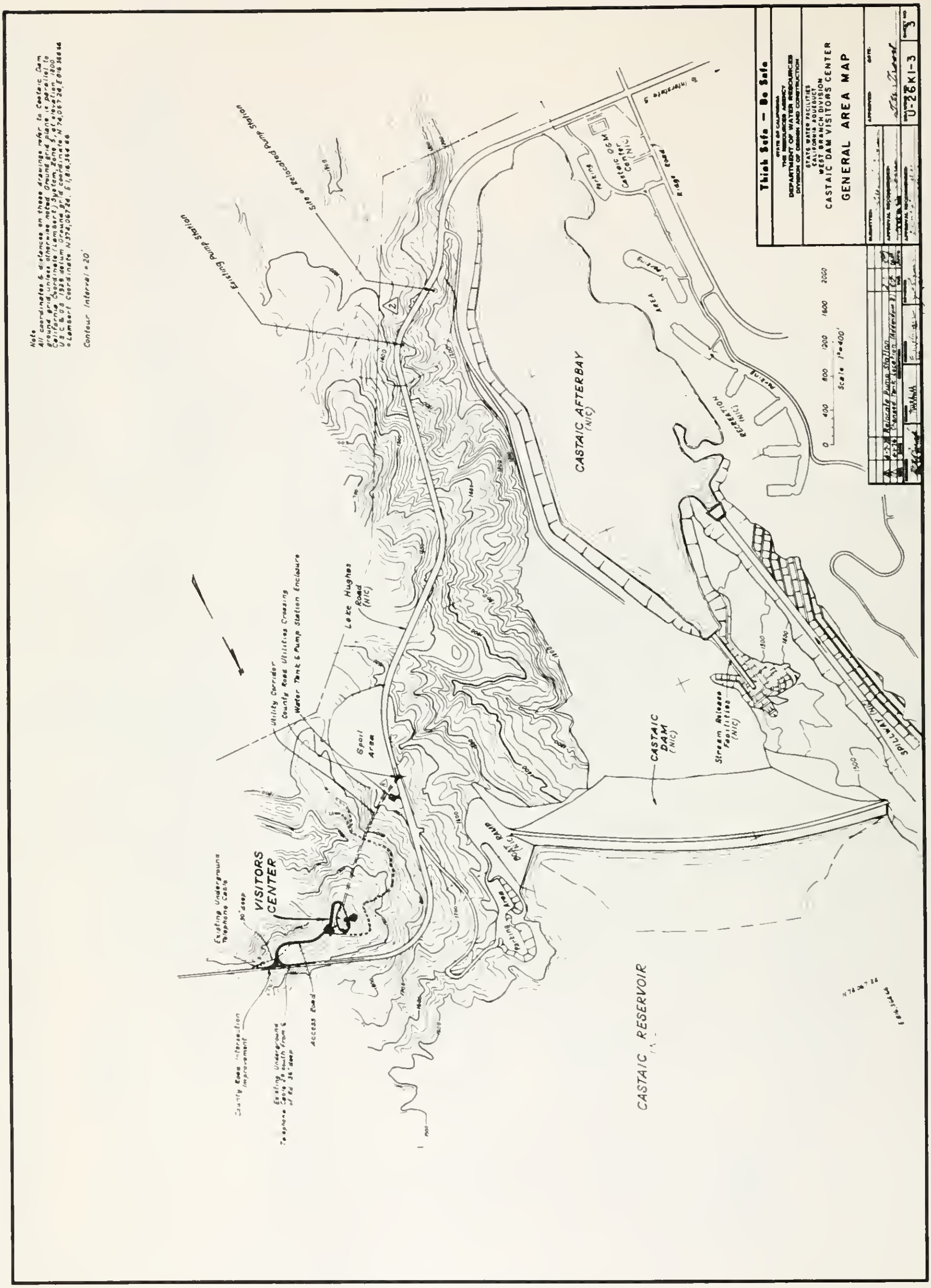

Figure 158. Location of Castaic Dam Visitors Center

Figure 159. Castaic Dam Visitors Center

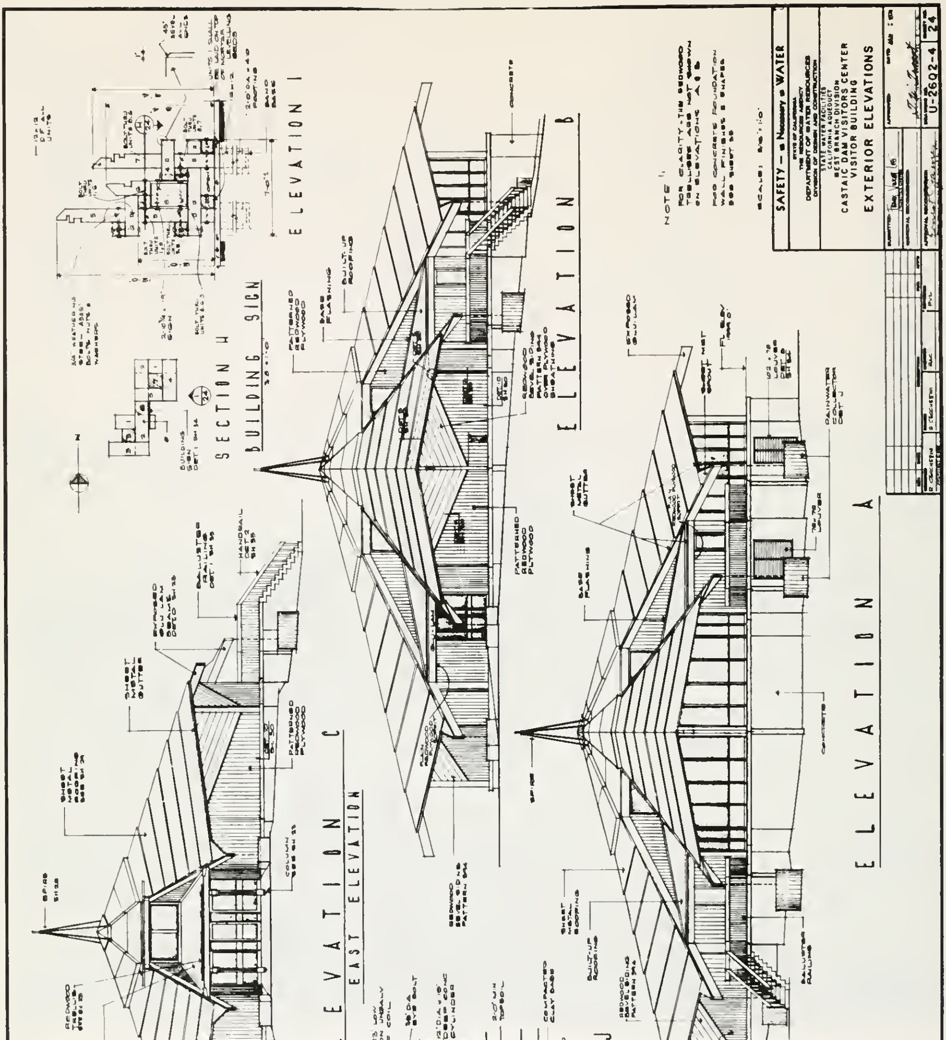

Figure 160. Castaic Dam Visitors Center—Elevations

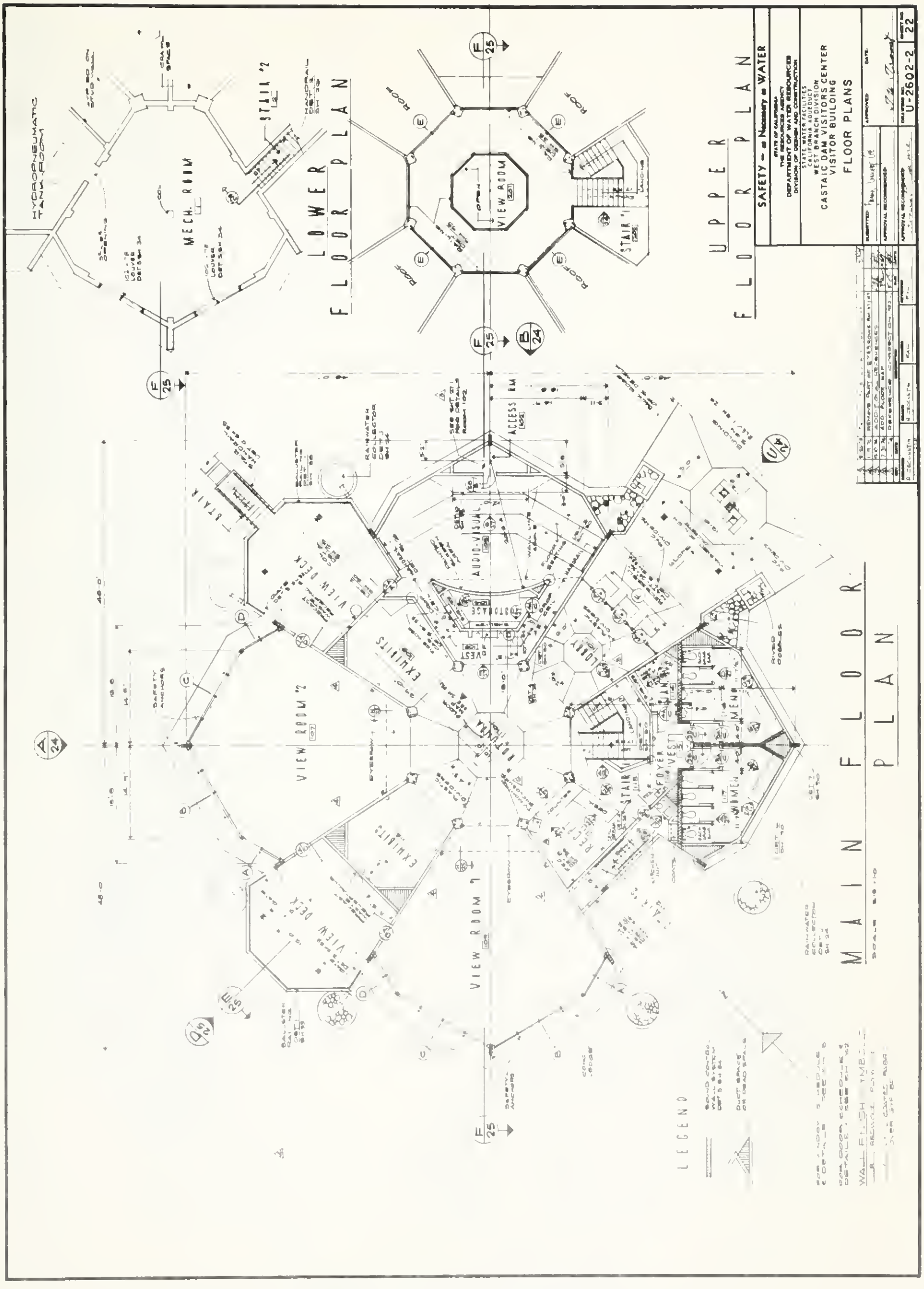

Figure 161. Castaic Dam Visitors Center—Floor Plan

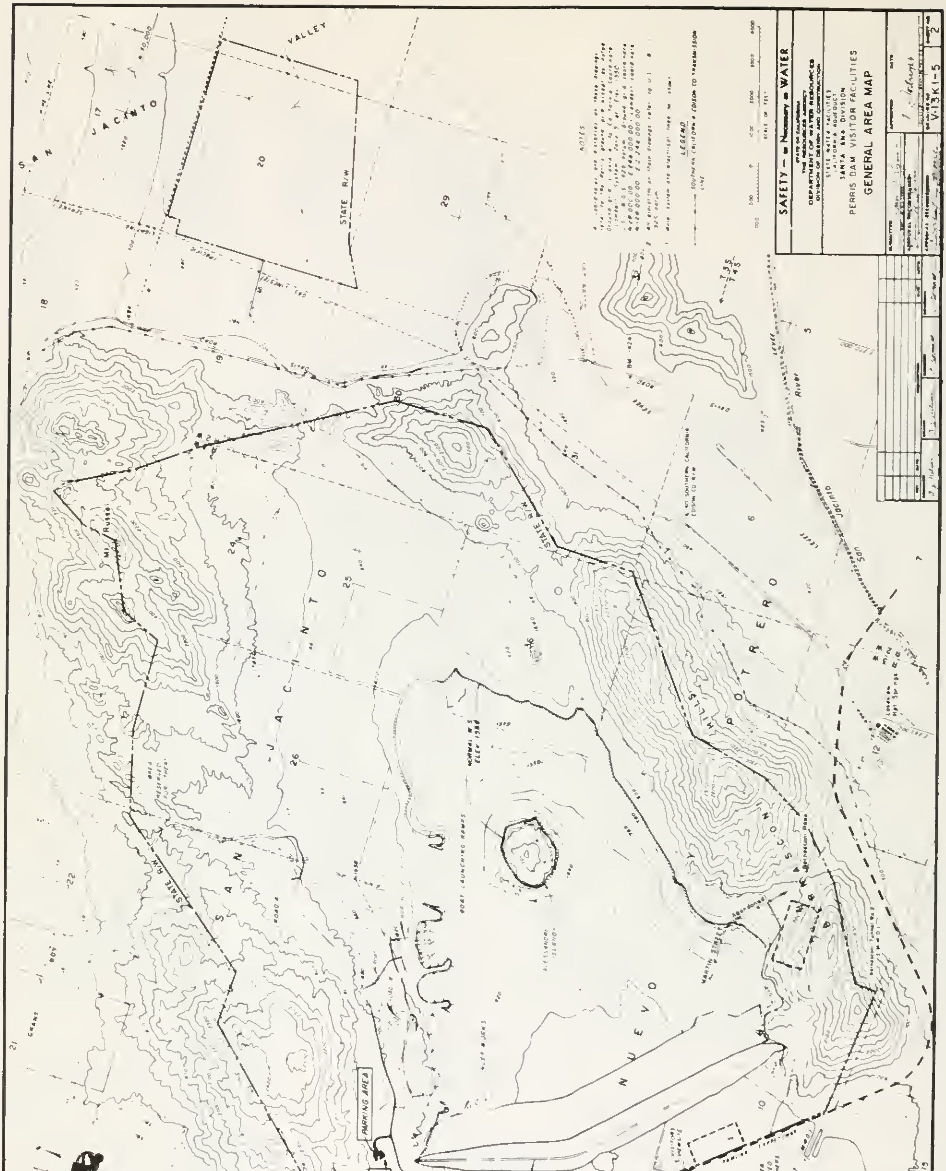

Figure 162. Location of Perris Dam Visitors Center

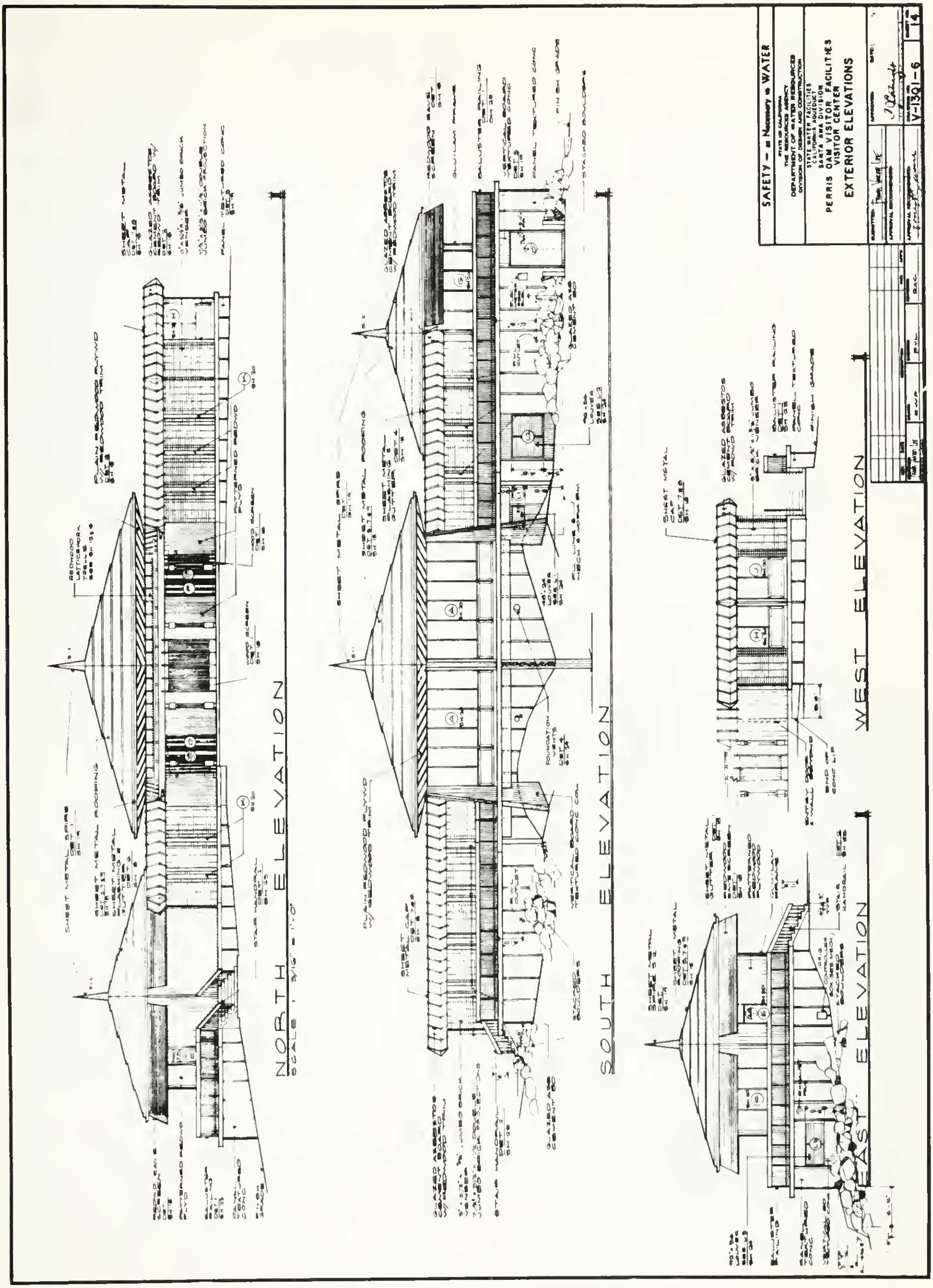

Figure 163. Perris Dam Visitors Center—Elevations

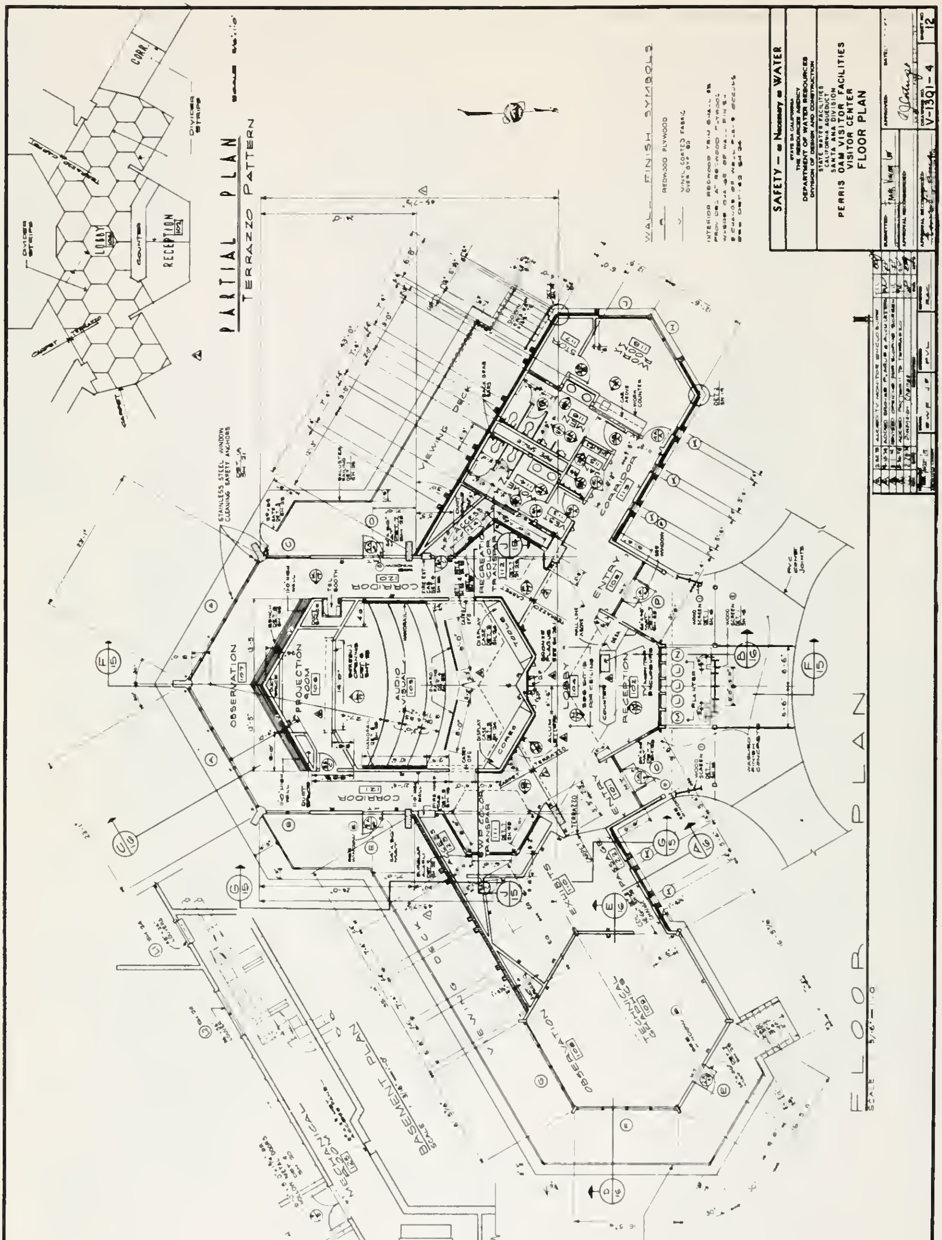

Figure 164. Perris Dam Visitors Center—Plan

CHAPTER X. ARCHEOLOGY

Introduction

The California State Water Project extends from the high valleys in the northern Sierra Nevada through the Great Valley of California to the Peninsular Ranges in the south. An inevitable side effect of an undertaking of such proportions is the disturbance or destruction of sites of historic or prehistoric importance. Because of interest in environmental considerations in relation to the State Water Project, the Department of Water Resources entered into a contract in 1960 with the Department of Parks and Recreation to survey the affected project areas and record or recover values of cultural significance. During the following decade, numerous archeological surveys and excavations were undertaken to carry out this task.

The interest in conserving valuable cultural resources has led to significant advances in the knowledge of California's prehistory. The archeological investigations funded by the Department provided a framework for future archeological research in several areas of California thus far unsurveyed. This chapter briefly describes the activities of an archeological nature. The basic data reports for several areas have been published, and additional reports of a scientific nature are under preparation.

In addition to the reports of a technical nature, the archeological program provided the Department of Parks and Recreation with a vast amount of material suitable for exhibit and interpretation. The interpretive programs for several of the water project units now under the jurisdiction of the Department of Parks and Recreation will benefit immensely from the archeological research carried out to save the affected cultural values.

Ultimately, all Californians will benefit since all will be able to understand better a little more about the earliest of California's pioneers.

High Sierra Nevada Valleys

The northernmost reaches of the State Water Project encompass three High Sierra Nevada valleys in which archeological investigations were undertaken. Although there is some doubt concerning the exact boundaries of sociopolitical influence, the area was inhabited in historic times by the Washo and the Maidu Indians.

Frenchman Lake

Evidence of prehistoric human occupation was discovered in a small canyon in the area known as Little Last Chance Valley. The site, designated as Chilcoot Rockshelter (Ca-Plu-44) *,was located at the base of an outcrop of volcanic rock at an elevation of 5,600 feet (Figure 165). It was one of a number of caves in the area, but none of the others showed evidence of human occupation.

Vegetation in the vicinity of the rockshelter was primarily Jeffrey Pine and sagebrush. Wild birds and mammals were abundant in the area, and a creek (Little Last Chance Creek) flowing just below the rockshelter contained fish and freshwater clams. Winters were severe and summers were cool with thundershowers common.

The site appears to have been an intermittent seasonal campsite, probably serving as a stopover place during summer hunting and fishing activities in the area. There is also evidence that the shelter may have been used as a hunting blind. In all likelihood, it was utilized by a single family or a group of no more than ten people. Archeological and ethnographic evidence indicate that the shelter was occupied intermittently between ca. (circa) A.D. 1400 and ca. A.D. 1850.

Antelope Lake

The Antelope Lake area was surveyed and no significant evidence of prehistoric human occupation was found.

Figure 165. Chilcoot Rockshelter in an Outcrop of Volcanic Rock

* Site designations follow the University of California archeological site survey system California is abbreviated Ca, and the counties are abbreviated with three-letter designations, i e , Plumas—Plu, Merced—Mer, etc The numbers are sequential for each county

Lake Davis

Grizzly Valley is a small High Sierra Nevada valley (elevation 5,800 feet) drained by three small streams, the largest of which (Big Grizzly Creek) presumably contained water all year. The valley floor was devoid of timber and covered with brush and grass (Figures 166 and 167). Dense stands of pine, cedar, and fir grew on the surrounding hills. The area would have been ideally suited for aboriginal occupation from an ecological standpoint, especially for groups with a hunting-gathering mode of life.

Fifteen archeological sites were found, each lacking significant midden (refuse heap) accumulation and each containing a scanty artifact sample. In view of the 6,000- to 7,000-year span of occupation postulated for the general region, the scarcity of cultural material is noteworthy and supports the thesis that the area was sparsely populated.

The survey did not find any evidence of large villages within the area. The archeological evidence suggests that primary utilization of the valley was for hunting and root collection, or possibly as a site for summer workshop camps. The size of the sites plus the limited amount of culturally derived material are indicative of small groups of people (one or two nuclear families) living in a specific location for short periods of time. Presumably, these people occupied the area only in the summer and did not return to the exact location on a systematic basis.

The above type of adaptation to the terrain is essentially the same as that practiced by the historic Washo. The artifactual material, however, is suggestive of occupation prior to the Washo or historic northeastern Maidu, that is, earlier than A.D. 1000.

Figure 166. Grizzly Valley

Figure 167. Big Grizzly Creek

Northern Sierra Nevada Foothills

Lake Oroville

The Oroville region of the northern Sierra Nevada foothills was inhabited in historic times by the Northwestern Hill Maidu, who utilized the two major plant communities (oak parkland and chaparral) of the Upper Sonoran Biotic Zone at elevations between 500 feet and 1,000 feet.

Archeological site surveys of the Oroville locale recorded over 200 sites, 145 of which have since been inundated.Subsequent archeological investigations indicated that the aboriginal occupants practiced a wide range of economic activities. The general pattern which emerged was that of a diversified local hunting and gathering economy with an acorn base, including utilization of many available vegetal food resources. Fishing also played an important role in the subsistence practices for groups along the Feather River. It is very likely that this subsistence pattern resulted in a "dense"population of the area (relative to the High Sierra Nevada valleys, for example).

Three village sites, each of which was probably inhabited by about 20 to 30 people at any one time, were excavated in the Oroville spillway area. Each village exhibited the remains of pine bark-covered pit houses (Figures 168 and 169). In general, the data suggest sporadic or intermittent aboriginal occupation between A.D. 1600 and A.D. 1850.

Several excavations (Figures 170, 171, and 172) of other sizable villages produced evidence of four separate prehistoric complexes in the Oroville area, the earliest of which (the Messilla complex) may date from ca. 2000 B.C. to ca. 1500 B. C. The next latest in time, the Bidwell complex, attests to occupation from ca. A.D. 1 to ca. A.D. 800. Following Bidwell, the Sweetwater complex extended from ca. A.D. 800 to ca.

Figure 168. Indian Village Site Under Excavation

Figure 170. Archeological Excavation in Progress—Oroville Reservoir Area

A.D. 1500 and, finally, the Oroville complex lasted from ca. A.D. 1500 to ca. A.D. 1850. Among the techniques utilized in dating these periods of habitation were radiocarbon dating, obsidian hydration dating, and the use of comparative artifact typology.

The archeological excavations suggest that the prehistoric settlement patterns in the Oroville locality represent the result of changing ecological adaptations to a specific microenvironment in the Upper Sonoran Biotic Zone.The culmination of these adaptive systems resulted in the historic Maidu subsistence pattern mentioned above, with its attendant, relatively high, population density.

Figure 171. Skeletal Remains—Oroville Reservoir

Figure 169 Remains of Pit House

Figure 172. Archeological Excavation in Progress—Thermalito Diversion Pool Area

In addition to salvaging valuable prehistoric cultural information, the Department of Water Resources arranged for the removal and safekeeping of several features of historical import in the Oroville area.The Bidwell Bar Bridge (Figures 173 and 174), the oldest suspension bridge in California, was disassembled and stored pending its reconstruction at the Kelly Ridge recreation area. The structural iron and the wire cables were transported to California via sailing ship around Cape Horn in the early 1850s. By 1856, the Bridge spanned the Feather River serving the needs of the historic Gold Rush town of Bidwell Bar.

At one side of the entrance to the Bridge stood an old stone building which served as the "tollkeeper's house". It, too, was dismantled and stored.

On the other side of the road stood the State's "Mother Orange Tree", the oldest orange tree in California. Planted in 1856, it was the first of its kind in this rugged terrain and its offspring produced a new industry in a section of California hundreds of miles north of any established citrus region.The tree has been boxed, removed, and transported to the Parks and Recreation Area Headquarters on Glen Drive, thus preserving one of California's true pioneers.

The Bridge and tollkeeper's house will be restored and reassembled near the Kelly Ridge recreation area in 1975. Cuttings from the "Mother Orange Tree" will be planted near the permanent location of the tree.

Thermalito Forebay

An archeological site survey of the Thermalito locale produced no significant evidence of human habitation.

The Delta and the Inner Coast Ranges

Clifton Court Forebay

Nothing of archeological significance was discovered while surveying the Clifton Court Forebay area.

Bethany Reservoir

Southeast of Mt. Diablo and east of Livermore Valley, the Inner Coast Ranges consist of a series of low rolling hills with little bold relief and equally little woody vegetation. For the most part, especially on their eastern margins adjoining the San Joaquin Valley and the Sacramento-San Joaquin Delta, these hills are covered with grass and herbaceous plants only.

Little is known concerning the specific group of Indians living there in historic times. The region is on the borderlines of territories historically claimed by the Northern Valley Yokuts, the Bay Miwok, and the Santa Clara Costanoans.

An archeological survey of the area discovered a burial estimated to be 1,500 years old and a chipped obsidian knife blade. Beyond these items, no evidence of former use of the area by Indians was discovered. This lack of evidence suggests that the region probably was used seasonally for gathering roots and bulbs or as a trading route. The probable reason for this limited and seasonal use was the aridity which prevented the growth of any significant quantity of economically important flora and the concomitant fauna.

Lake Del Valle

The Lake Del Valle area is within the territory historically claimed by the Santa Clara Indians, a Costanoan-speaking group. An archeological site survey

Figure 173. Bidwell Bar Bridge and Toll House

Figure 174. Bidwell Bar Bridge

of the locality did not find any evidence of Indian occupation.

The Eastern Foothills of the Diablo Range

San Luis Reservoir

Thirty-seven sites were discovered in the San Luis Reservoir area in the eastern foothills of the South Coast Range.

The site designated Ca-Mer-14 (Figure 175) was located on San Luis Creek, one-quarter mile above its confluence with Cottonwood Creek and about 20 miles southwest of the main course of the San Joaquin River. It lies at an elevation of 250 feet at the mouth of San Luis Flat. The area is within the limits of the territory historically claimed by the Northern Valley Yokuts. The site was primarily a cemetery (106 burials were recorded, one of which is shown in Figure 176). Some caution must be exercised in making economic interpretations, but the evidence indicates a mixed economy utilizing plant, mammal, fish, and shellfish resources. No artifactual evidence of fishing was found, but some jacksmelt scales and a few pieces of freshwater clam shell were unearthed. The dearth of projectile points in comparison with grinding tools probably indicates heavier reliance on seed gathering rather than hunting. Recovery of various bead types associated with the burials indicates that the site represents a single cultural component which has been termed the Gonzaga complex and provisionally is dated from ca. A.D. 500 to ca. A.D. 1000.

Figure 175 Indian Village and Cemetery Site Under Excavation

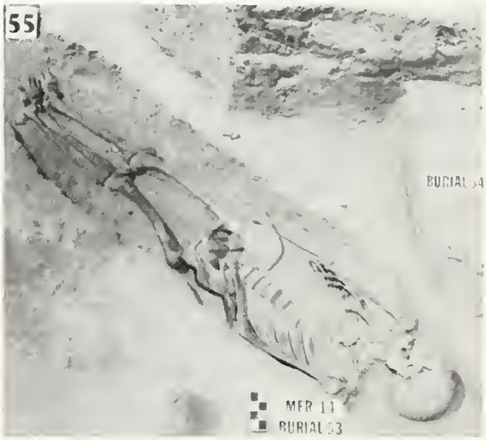

Figure 176. Skeletal Remains—San Luis Reservoir

The site designated Ca-Mer-S94 was located at the edge of oak-dominated uplands in a narrow valley at the foot of Pacheco Pass (Figure 177). It is situated on a low terrace remnant just above a small streambed at an elevation of 400 feet. The uplands location of this site probably contributed to the differences in deposit between it and the other excavations carried out in the general region. The site does not relate at all closely to the Ca-Mer-14 site or to the sites excavated at Los Banos Reservoir or Little Panoche Reservoir. The depth distribution of the midden constituents suggests two intensive periods of occupation. The earliest complex, termed the Positas complex, is estimated to be more than 2,000 years old. There is only a trace of the protohistoric Panoche complex present in the site. The materials occurring between the earliest and latest components are subject to conjecture at present but provisionally can be dated from ca. A.D. 500 to ca. A.D. 1000. Radiocarbon dates, when matched with artifact types, exhibit very little "fit" compared with other sites and known regional typologies. There appears to be an affinity to the west or southwest, e.g., the projectile point assemblage of the lower portions of the deposit suggests a relationship with the south coast, while the beads and ornaments suggest a Central Valley source. Extensive rodent disturbance of the site may have mixed the deposit enough to have created the previously mentioned problems. Future radiocarbon dating of other materials from the site may help resolve the problem.

The site designated as Ca-Mer-S130 (Figure 178) was located in the uplands rather than on or near the alluvial fans of the valley proper. It was due east of Pacheco Pass at an elevation of approximately 650 feet and was in an area of scattered oaks and buckeye. A small spring was located in the main east-west canyon upon which the site was located. Ca-Mer-S130 was probably an outlier of a large village 100 feet to the south. Initial occupation of the site probably occurred during the Gonzaga period (ca. A.D. 500 to ca. A.D. 1000), but the major occupation was during the Panoche period (ca. A.D. 1500 to ca. A.D. 1800). It appears to have been occupied on a seasonal basis, and there is evidence of trade in locally manufactured stone objects with people living to the east in the San Joaquin Valley.

Los Banos Reservoir

An archeological excavation was undertaken at site Ca-Mer-3 (Figures 179 and 180) in the Los Banos Reservoir area, which was part of the territory historically claimed by the Kawatchwa branch of the Northern Valley Yokuts. The area was characterized by short grasses and low shrubs. Six miles to the west were heavy growths of live oak and black oak. A few miles to the east, a vast riverine environment existed which contained fish and large and small mammals. The seed grasses in the immediate vicinity of the site were most

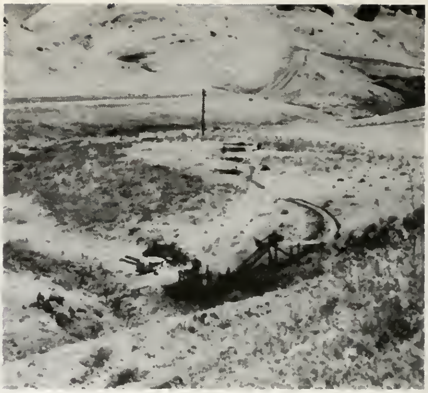

Figure 177. Archeological Excavation in Progress—Pacheco Pass

Figure 178. Archeological Excavation in Progress—East of Pacheco Pass

Figure 179. Excavation of Indian House Pit—Los Banos Reservoir Area

Figure 180. Los Banos Reservoir Area

Figure 181. Archeological Excavation in Progress—Little Panoche Valley

Figure 182. Skeletal Remains—Little Panoche Valley

likely an important resource for the prehistoric and protohistoric occupants.

Two cultural and temporal components were indicated by 22 primary burials and 32 cremations in stratigraphic context. Nine extended burials and the variety of artifacts associated with them are indicative of Gonzaga period occupation (as expressed at Ca-Mer-14 in the San Luis Dam area), while the cremations are attributable to a specialized phase of the Panoche period.

Twelve structures of both a ceremonial and domicile nature were excavated. These, along with the cremations, clearly represent a protohistoric occupation with cultural relationships to both Central and Southern California.

Little Panoche Reservoir

Little Panoche Valley is situated on the extreme western edge of the San Joaquin Valley at an elevation of 500 feet to 600 feet. It is bordered on the west by the Diablo Range. The area is characterized by a series of abruptly defined low mountains, rising to an elevation of 1,500 to 2,000 feet and a broad alluvial fan which drops off to the east toward the center of the San Joaquin Valley. The hills are broken by a series of well-defined, stream-cut valleys or canyons trending in an east-west direction which have cut into the alluvial fan for some distance out into the valley floor. The general area is included within the territory historically claimed by the western San Joaquin Valley Yokuts.

Two sites were excavated in the Little Panoche Valley (Figure 181). The site designated Ca-Fre-128 produced evidence of occupation by a relatively small group of people on a seasonal basis in protohistoric and early contact times. The artifact assemblage appears to have definite links with groups to the south or west rather than to the north. Artifactual and ethnographic evidence suggests that the entire span of occupation was from ca. A.D. 1500 to ca. A.D. 1800.

The site designated Ca-Fre-129 was most likely an intensively used summer campsite. A small cemetery was excavated, and the burials plus associated artifacts are typical of the late occupation of the area (Figure 182). There was no evidence of structures at the site, and the midden accumulation lacked appreciable depth. The economy must have been based on hunting and seed or acorn gathering. The area in general was rather desolate, and it is highly likely that nearby stands of "arrowcane" were the chief attractions of the locale (Figure 183). Arrow straighteners found during excavation indicate the existence of arrow manufacturing.

The protohistoric period in the San Luis-Little Panoche region is known from at least four excavated sites and two unexcavated sites. This protohistoric occupation has been named the "Panoche complex", since it is best defined from sites Ca-Fre-128 and Ca-Fre-129 where the entire occupation is assigned to the Late period.

Figure 183. Arrowcane Growing in Little Panache Valley

Figure 184. Archealogical Site at Buena Vista Lake

The California Aqueduct

Sites Along the California Aqueduct

An archeological site survey along the California Aqueduct produced evidence of 17 sites, only one of which was excavatable (Buena Vista Lake).

Buena Vista Lake

A midden site designated as Ca-Ker-116 was discovered on the shoreline of the now extinct Buena Vista Lake in the southwest corner of the San Joaquin Valley. The area is within the territory historically claimed by the Tulamni, a southern Valley Yokuts group. The midden, which was approximately 4 feet deep, proved to be entirely prehistoric. Excavation continued through 8 feet of culturally sterile soil and, at a depth of 12 feet, the ancient lake shore was discovered. Resting upon this ancient shoreline were cultural artifacts of chipped stone in conjunction with freshwater clam shells. Radiocarbon dating of the shells provided evidence of human occupation of the lake area approximately 8,000 years ago. The site represents one of the earliest known occupations of the San Joaquin Valley (Figures 184 and 185).

The Peninsular Ranges

Silverwood Lake

A site survey of the Silverwood Lake area indicated five sites of possible archeological interest. Further investigation revealed that none of the sites warranted excavation or further consideration.

Lake Perris

The Lake Perris area is a broad valley bounded by the San Jacinto Mountains to the east, San Bernardino Mountains to the north, the Santa Ana Mountains to the southwest, and the Santa Ana River to the northwest. The topography is dominated by two northeast-southwest trending granitic ridges, Mount Russell to the north and the Bernasconi Hills to the south. The area is roughly 1,400 feet above sea level. The principal water sources are small scattered springs. Five major biotic communities are represented: range grassland, coastal sage scrub, chaparral, marsh, and alkali flats. There are large and small game in the area, including marsh and upland avifauna.

There isn't any certain knowledge of what sociopolitical group occupied the region in historic times. The Serrano occupied the territory to the north, the Gabrielino to the west, the Luiseno to the south, and the Cahuilla inhabited the areas to the east.

Sixty-one sites were found in the Lake Perris locality. Two major types of sites were defined (occupation sites and food processing sites), and a third type consisted of isolated pictograph or petroglyph sites.

The occupation sites were found at the base of hills or at the mouths of small canyons where spring water is available. They were characterized by the presence of relatively deep middens and bedrock mortars used in the preparation of acorns or hollyleaf cherries. The evidence indicates that they were temporary villages or campsites and that there were two periods of occu-

Figure 185. Archealogical Excavation in Canal Right of Way

pation in this region. Radiocarbon dating and comparative artifact typology indicate an early use of the area from ca. 300 B.C. to ca. A.D. 1300. A late period of habitation began around A.D. 1300 and lasted until about A.D. 1800. During this time, the resources were used more intensively than in the past.

After ca. A.D. 1600, ceramicware was used for food processing and storage, and there was a reciprocal exchange system which included not only groups on the Pacific Coast but also people along the Gulf of California.

The food processing sites consisted primarily of bedrock milling surfaces used in the preparation of a variety of herbs and grass seeds. There were approximately five times as many of these types of sites as there were occupation sites.

The general picture which emerges shows an area which was inhabited seasonally to utilize a wide variety of plant and animal foods and that this pattern extends back for some 2,000 years.

The Southern California Transverse Ranges

Pyramid Lake

Pyramid Lake, in the upper Santa Clara River Valley region, encompasses a portion of the upper reach of Piru Creek in northwestern Los Angeles County. The area is rugged and brush-covered except for the flats and low bluffs adjacent to the creekbed. A few oaks occur in the central section of the locality, a fact which undoubtedly enhanced its value to the prehistoric inhabitants.

The specific tribal attribution for the region is unclear, but it was on the border of territories claimed by the little-known Alliklik group (a northern branch of the Shoshonean-speaking Serrano) and the Chumash groups to the west.

Ten sites were recorded and totally surface collected. The yield of cultural items was relatively low; and the sites were mainly small and shallow, attesting to a sporadic, temporary, seasonal hunting-gathering adaptation to an arid environment (Figure 186).

Castaic Lake

The Castaic Lake area is within the limits of the territories attributed to the previously mentioned Alliklik. This group practiced an arid-lands adaptation in the canyons and mountains of the upper Santa Clara River Valley (Figure 187).

Of the five sites that were discovered in the area, four were special use sites for processing food, and one was a larger site containing several distinct activity areas and exhibiting two separate periods of occupation. This larger site was located on a complex alluvial fan system near the confluence of Elderberry and Castaic Creeks. The site consisted of a deep midden, a bedrock mortaring area, and an associated cemetery, all of which indicated a permanent, long-term occupation. A stylistic analysis of the artifacts and two radiocarbon dates showed that the original inhabitants had occupied the area during the period of ca. A.D. 1 to ca. A.D. 800.

A second population reoccupied a portion of the site around A.D. 1200. This part of the site seems to have been a seasonal base camp, inhabited from spring through fall. There is evidence that, at the time of occupation, the hillsides around the site were covered with sage and chaparral. These vegetation communities provided ample wild foodstuffs and would have supported an adequate faunal population to have made hunting and gathering activities very profitable. Anywhere from five to ten households (30 to 60 people) may have occupied the site at any one time. Osteological evidence indicates that this later population did not exploit large game to the extent the earlier population had. This later period of habitation most likely represents the Alliklik, who were absorbed into the missions with the other Shoshonean-speaking people around A.D. 1800.

Quail Lake

An archeological site survey of the Quail Lake region did not produce any significant evidence of prehistoric occupation.

Figure 186. Alliklik Indian Site—Pyramid Reservoir Area

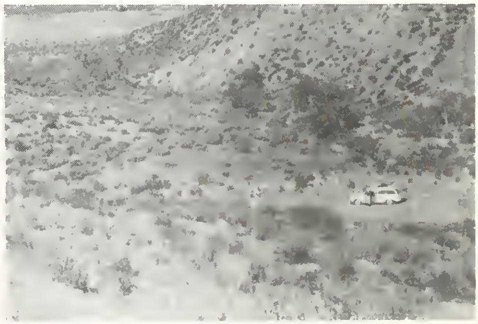

Figure 187. Alliklik Indian Site—Castaic Reservoir Area

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** Archeological reports are publications of the California Department of Parks and Recreation, Sacramento.

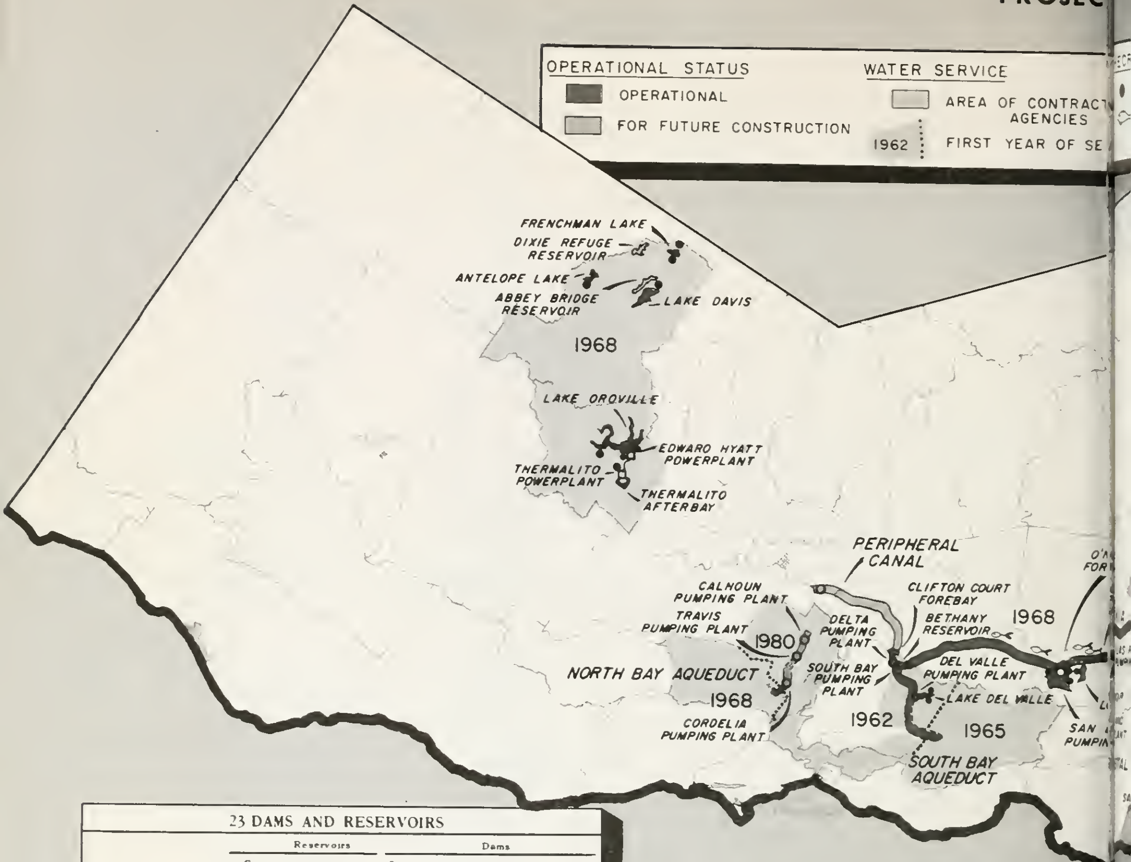
APPENDIX A
ENGLISH TO METRIC CONVERSIONS AND PROJECT STATISTICS

CONVERSION FACTORS

English to Metric System of Measurement

Quantity	English unit	Multiply by	To get metric equivalent
Length	inches	2.54	centimeters
	feet	30.48	centimeters
		0.3048	meters
		0.0003048	kilometers
	yards	0.9144	meters
	miles	1,609.3	meters
		1.6093	kilometers
Area	square inches	6.4516	square centimeters
	square feet	929.03	square centimeters
	square yards	0.83613	square meters
	acres	0.40469	hectares
		4,046.9	square meters
		0.0040469	square kilometers
	square miles	2.5898	square kilometers
Volume	gallons	3,785.4	cubic centimeters
		0.0037854	cubic meters
		3.7854	liters
	acre-feet	1,233.5	cubic meters
		1,233,500.0	liters
	cubic inches	16.387	cubic centimeters
	cubic feet	0.028317	cubic meters
	cubic yards	0.76455	cubic meters
		764.55	liters
Velocity	feet per second	0.3048	meters per second
	miles per hour	1.6093	kilometers per hour
Discharge	cubic feet per second or second-feet	0.028317	cubic meters per second
Weight	pounds	0.45359	kilograms
	tons (2,000 pounds)	0.90718	tons (metric)
Power	horsepower	0.7460	kilowatts

PROJEC



23 DAMS AND RESERVOIRS

Name of Reservoir	Reservoirs: Gross Capacity(1 (Acre-feet)	Reservoirs: Surface Area (acres)	Reservoirs: Shore-line (miles)	Dams: Structural Height (feet)	Dams: Crest Elevation(2 (feet)	Dams: Crest Length (feet)	Dams: Volume (cubic yards)
Frenchman Lake	55,477	1,580	21	139	5,607	720	537,000
Antelope Lake	22,566	931	15	120	5,025	1,320	380,000
Lake Davis	84,371	4,026	32	132	5,785	800	253,000
Abbey Bridge	45,000	1,950	21	117	5,475	1,150	500,000
Dixie Refuge	16,000	900	15	100	5,754	1,050	400,000
Lake Oroville	3,537,577	15 805	167	770	922	6 920	80,000,000
Thermalito Diversion Pool	13,328	323	10	143	233	1,300	154 000
Fish Barrier Pool	580	52	1	91	181	600	10,500
Thermalito Forebay	11,768	630	10	91	231	15,900	1 840,000
Thermalito Afterbay	57,041	4 302	26	39	142	42,000	5 020,000
Clifton Court Forebay	28,653	2,109	8	30	14	36 500	2 440,000
Bethany	4,804	161	6	121	250	3 940	1 400 000
Lake Del Valle	77,106	1,060	16	235	773	880	4 150 000
San Luis	2,038,771	12,700	65	385	554	18 600	77,645,000
O'Neill Forebay	56,426	2,700	12	88	233	14,350	3,000,000
Los Banos	34,562	623	12	167	384	1,370	2,100 000
Little Panoche	13,236	354	10	152	676	1,440	1,210,000
Buttes	21 800	580	6	190	2,790	2 230	3,130,000
Silverwood Lake	74 970	976	13	249	3,378	2,230	7,600,000
Lake Perris	131 452	2,318	10	128	1,600	11,600	20,000,000
Pyramid Lake	171,196	1,297	21	400	2,606	1,090	6,860,000
Elderberry Forebay	28,231	460	7	200	1,550	1,990	6,000,000
Castaic Lake	323,702	2,235	29	425	1,535	4 900	46,000,000
Totals	6,848,617	56,072	533			172,880	270,629,500

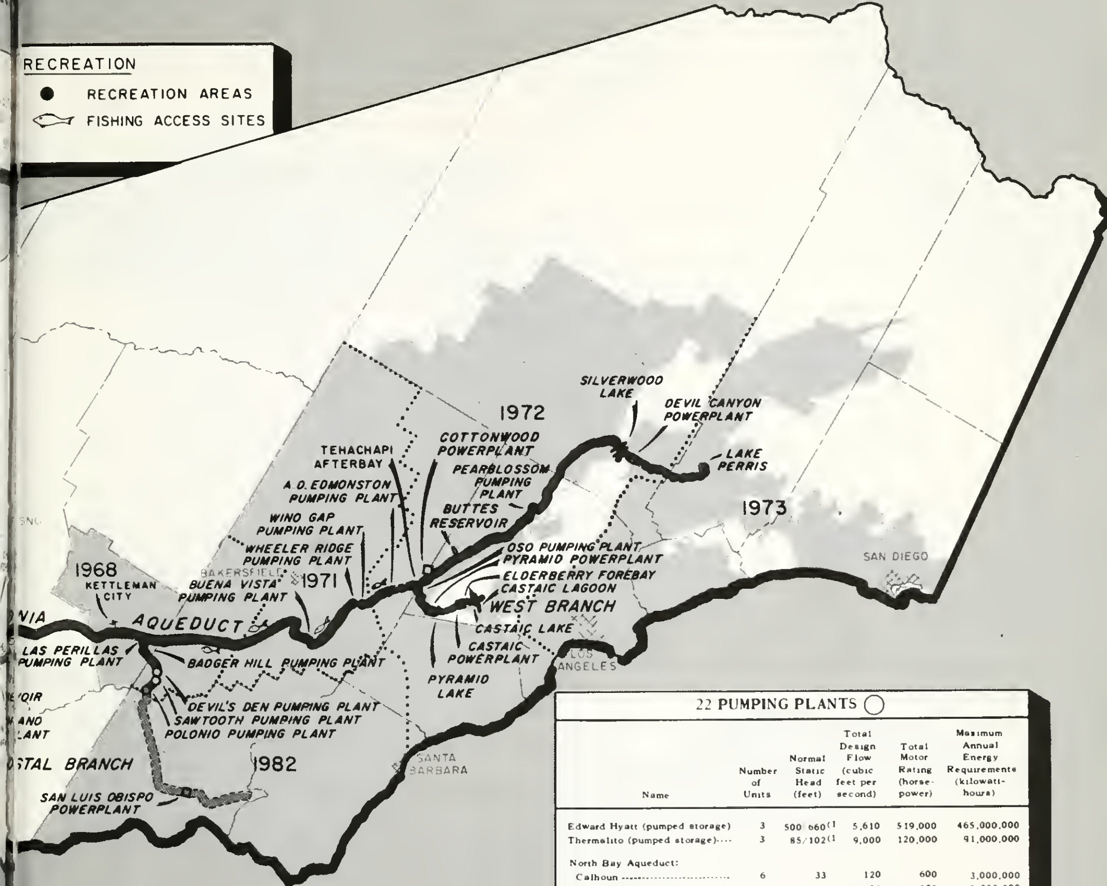
1) At maximum normal operating level

2) Above sea level.

AQUEDUCTS

Name	Length (miles): Total	Canal	Pipeline	Tunnel	Channel and Reservoir
North Bay Aqueduct	26.5	14.3	12 2	0	0
South Bay Aqueduct	42 9	8 4	32.9	1 6	0
Peripheral Canal	43.0	42 0	1 0	0	0
Subtotal	112.4	64.7	46.1	1 8	0
California Aqueduct (main line):					
Delta to O'Neill Forebay	68 4	67 0	0	0	1 4
O'Neill Forebay to Kettleman City	105.7	103.5	0	0	2 2
Kettleman City to A. D. Edmonston Pumping Plant	120 9	120.9	0	0	0
A. D. Edmonston Pumping Plant thru Tehachapi Afterbay	10 6	0.2	2.5	7 9	0
Tehachapi Afterbay thru Lake Perris	138 4	93 4	38 3	3 8	2 9
Subtotal, main line	444.0	385 0	40 8	11 7	8 5
California Aqueduct (branches):					
West Branch	31.9	9.1	6 4	7 2	9 2
Coastal Branch	96 2	14 8	81 4	0	0
Subtotal, branches	128 1	23 9	87 8	7.2	9 2
Totals	684.5	473.8	174 7	20 5	15 7

STATISTICS



22 PUMPING PLANTS

Name	Number of Units	Normal Static Head (feet)	Total Design Flow (cubic feet per second)	Total Motor Rating (horse-power)	Maximum Annual Energy Requirements (kilowatt-hours)
Edward Hyatt (pumped storage)	3	500/660(1	5,610	519,000	465,000,000
Thermalito (pumped storage)	3	85/102(1	9,000	120,000	91,000,000
North Bay Aqueduct:					
Calhoun	6	33	120	600	3,000,000
Travis	6	0	120	900	5,000,000
Cordelia	3	448	48	3,100	14,000,000
South Bay Aqueduct:					
South Bay	9	545	330	27,750	166,000,000
Del Valle	4	0/38(2	120	1,000	2,000,000
California Aqueduct (main line):					
Delta	11	244	10,303	333,000	1,355,000,000
San Luis					
Total	8	99/327(2	11,000	504,000	
State Share			5,762	264,000	313,000,000
Dos Amigos					
Total	6	113	13,200	240,000	
State Share			7,100	130,000	607,000,000
Buena Vista	10(3	205	5,049	136,000	746,000,000
Wheeler Ridge	9(3	233	4,598	140,000	797,000,000
Wind Gap	9(3	518	4,410	308,000	1,761,000,000
A. D. Edmonston	14(3	1,926	4,095	1,040,000	5,916,000,000
Pearblossom	6	540	1,380	113,200	647,000,000
California Aqueduct (branches):					
Oso	8	231	3,128	93,800	446,000,000
Las Perillas	6	55	450	4,050	20,000,000
Badger Hill	6	151	450	10,500	56,000,000
Devil's Den	4	409	126	8,000	51,000,000
Sawtooth	4	331	126	6,500	41,000,000
Polonio	4	810	126	16,000	101,000,000
Peripheral Canal					
Total	9(3	10	21,800	35,200	
State Share			10,900	17,440	88,000,000
Total, State Share					13,691,000,000

1) Minimum and maximum total pumping heads.
2) Minimum and maximum static heads
3) Includes one spare unit.

8 POWERPLANTS

Name	Number of Units	Normal Static Head (feet)	Total Design Flow (cubic feet per second)	Power Generator Output (kilowatts)	Maximum Annual Energy Output (kilowatt-hours)
Edward Hyatt	6	410/676(1	14,550	678,750	2,475,000,000
Thermalito	4	85/100(1	16,900	119,600	383,000,000
San Luis					
Total	8	99/327(1	13 120	424,000	
State Share			6 872	222,100	170,000,000
Cottonwood	1	140	1 637	15,000	115,000 000
Devil Canyon	2	1,418	1 200	119 700	1,003,000,000
Pyramid	2	740	3,100	157,000	1,001,000,000
Castaic					
Total	7	1,063	18 400	1,250,000	
State Share(2			3,092	214,000	1,457,000,000
San Luis Obispo	1	730	111	5,900	41,000,000
Total, State Share					6,645,000,000

1) Minimum and maximum static heads
2) The City of Los Angeles Department of Water and Power will construct and operate a 1,250,000-kilowatt Castaic Powerplant and will supply the Project with electrical power and energy equivalent to the generation from a 213,984 kilowatt powerplant the State originally planned to construct

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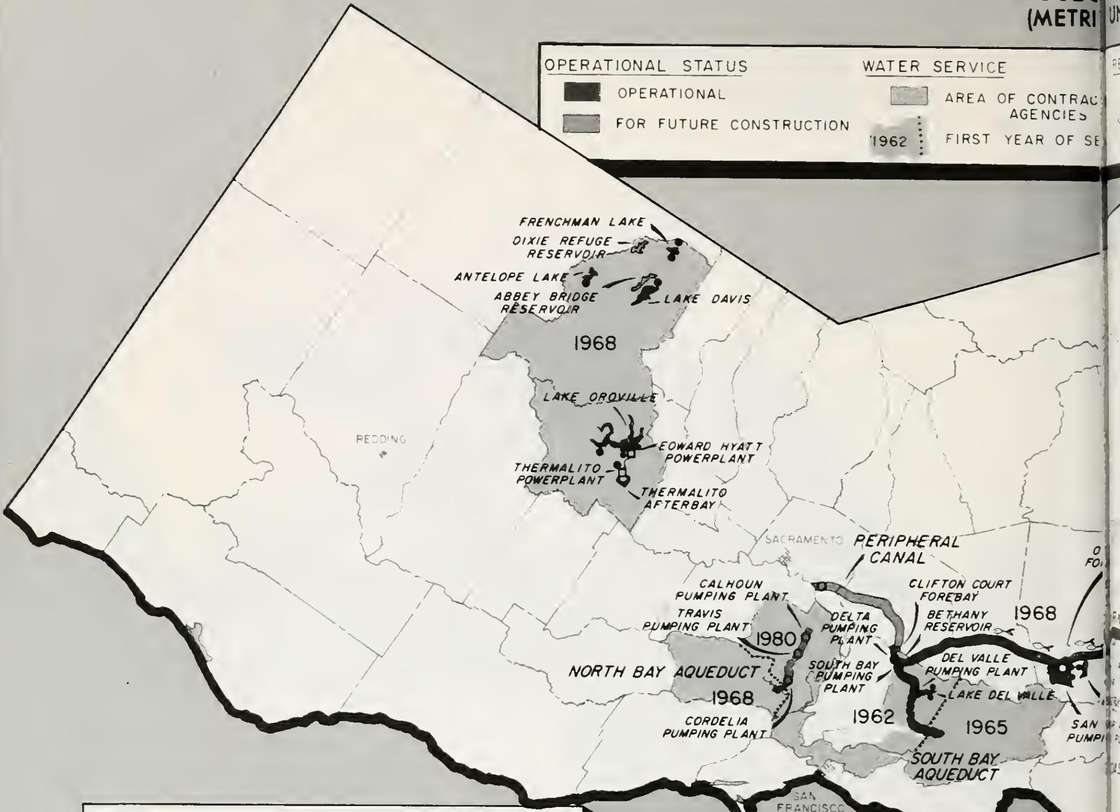

23 DAMS AND RESERVOIRS

	Reservoirs				Dams		
Name of Reservoir	Gross Capacity 1/ (millions of cubic meters)	Surface Area (hectares)	Shore-line (kilo-meters)	Struc-tural Height (meters)	Crest Eleva-tion 2/ (meters)	Crest Length (meters)	Volume (cubic meters)
Frenchman Lake	68.43	639	33.8	42	1709	219	410,600
Antelope Lake	27.84	377	24.1	37	1532	402	290,500
Lake Davis	104.07	1,629	51.5	40	1763	244	193,400
Abbey Bridge	55.51	769	33.8	36	1669	351	382,300
Dixie Refuge	19.74	364	24.1	30	1754	320	305,800
Lake Oroville	4,363.60	6,396	268.8	235	281	2,109	61,164,000
Thermalito Diversion Pool	16 44	131	16 1	44	71	396	117,700
Fish Barrier Pool	0.72	21	1.6	28	55	183	8,000
Thermalito Forebay	14.52	255	16.1	28	70	4,846	1,406,800
Thermalito Afterbay	70,36	1,741	41.8	12	43	12,802	3,838,000
Clifton Court Forebay	35 34	653	12.9	9	4	11,125	1,865,500
Bethany	5.93	65	9.7	37	76	1,201	1,070,300
Lake Del Valle	95.11	429	25.8	72	236	266	3,172,900
San Luis	2,514.82	5,140	104.6	117	169	5,669	59,363,500
O'Neill Forebay	69.60	1,093	19.3	27	71	4,374	2,293,700
Los Banos	42.63	252	19.3	51	117	418	1,605,600
Little Panoche	16 33	143	16.1	46	206	439	925,100
Buttes	26.89	235	9.7	58	850	660	2,393,000
Silverwood Lake	92.46	395	20.9	76	1,030	660	5,610,600
Lake Perris	162.15	936	16 1	39	466	3,536	15,291,000
Pyramid Lake	211.17	525	33.8	122	794	332	5,244,800
Elderberry Forebay	34 62	166	11.3	61	472	607	4,567,300
Castaic Lake	399 29	904	46.7	130	466	1,494	35,169,300
Totals	8,447 79	23,500	657.9			52,695	206,909,700

1/ At maximum normal operating level.
2/ Above sea level.

AQUEDUCTS

	Length (kilometers)				
Name	Total	Canal	Pipeline	Tunnel	Channel and Reservoir
North Bay Aqueduct	42.6	23 0	19 6	0	0
South Bay Aqueduct	69.1	13.5	53.0	2.6	0
Peripheral Canal	69.2	67 6	1 6	0	0
Subtotal	180.9	104.1	74.2	2.6	0
California Aqueduct (main line):					
Delta to O'Neill Forebay	110.1	107.6	0	0	2.3
O'Neill Forebay to Kettleman City	170.1	166.6	0	0	3.5
Kettleman City to A.D. Edmonston Pumping Plant	194.6	194.6	0	0	0
A.D. Edmonston Pumping Plant thru Tehachapi Afterbay	17 0	0 3	4 0	12 7	0
Tehachapi Afterbay thru Lake Perris	222.7	150 3	61 6	6 1	4 7
Subtotal, main line	714 5	619 6	65.6	18.8	10.5
California Aqueduct (branches):					
West Branch	51.3	14.6	10.3	11.6	14.8
Coastal Branch	154.8	23.8	131.0	0	0
Subtotal, branches	206 1	38.4	141.3	11.6	14 8
TOTALS	1,101.5	762.1	281.1	33.0	25.3

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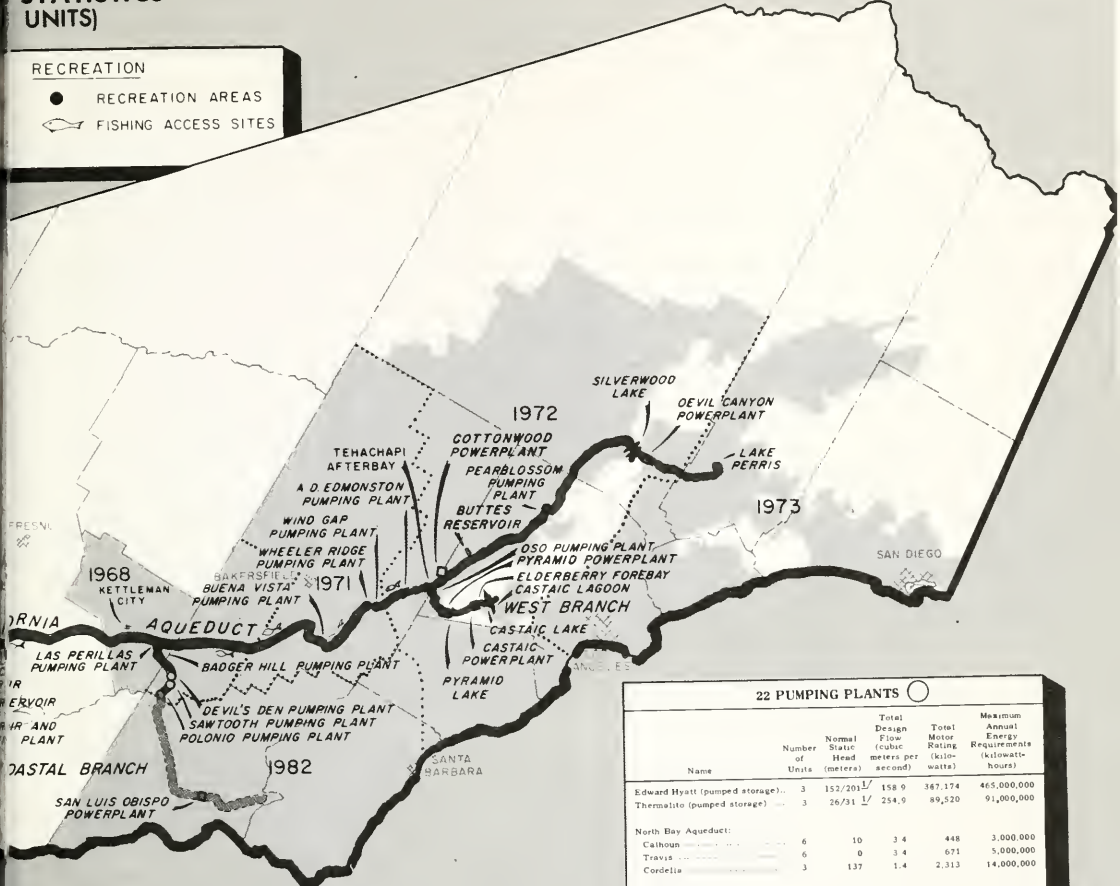

8 POWERPLANTS

Name	Number of Units	Normal Static Head (meters)	Total Design Flow (cubic meters per second)	Power Generator Output (kilowatts)	Maximum Annual Energy Requirements (kilowatt-hours)
Edward Hyatt	6	125/206 1/	412 0	678,750	2,475,000,000
Thermalito	4	26/30 1/	478.6	119,600	383,000,000
San Luis					
Total	8	30/100 1/	371.6	424,000	
State Share			194.6	222,100	170,000,000
Cottonwood	1	43	46.4	15,000	115,000,000
Devil Canyon	2	432	34.0	119,700	1,003,000,000
Pyramid	2	226	87 8	157,000	1,001,000,000
Castaic					
Total	7	324	521.0	1,250,000	
State Share 2/			87.6	214,000	1,457,000,000
San Luis Obispo	1	223	3 1	5,900	41,000,000
Total, State Share					6,645,000,000

1/ Minimum and maximum static heads.

2/ The City of Los Angeles Department of Water and Power will construct and operate a 1,250,000-kilowatt Castaic Powerplant and will supply the Project with electrical power and energy equivalent to the generation from a 213,984-kilowatt powerplant the State originally planned to construct.

22 PUMPING PLANTS

Name	Number of Units	Normal Static Head (meters)	Total Design Flow (cubic meters per second)	Total Motor Rating (kilo-watts)	Maximum Annual Energy Requirements (kilowatt-hours)
Edward Hyatt (pumped storage)	3	152/201 1/	158 9	367,174	465,000,000
Thermalito (pumped storage)	3	26/31 1/	254.9	89,520	91,000,000
North Bay Aqueduct:					
Calhoun	6	10	3 4	448	3,000,000
Travis	6	0	3 4	671	5,000,000
Cordelia	3	137	1.4	2,313	14,000,000
South Bay Aqueduct:					
South Bay	9	166	9.3	20,702	166,000,000
Del Valle	4	0/12 2/	3.4	746	2,000,000
California Aqueduct (main line):					
Delta	11	74	291.8	248,418	1,355,000,000
San Luis					
Total	8	30/100 2/	311.5	375,984	
State Share			163.2	196,944	313,000,000
Dos Amigos					
Total	6	34	373 8	179,040	
State Share			201 1	96,980	607,000,000
Buena Vista	10 3/	62	143.0	101,456	746,000,000
Wheeler Ridge	9 3/	71	130 2	104,440	797,000,000
Wind Gap	9 3/	158	124.9	229,768	1,761,000,000
A.D. Edmonston	14 3/	587	116 0	775,840	5,916,000,000
Pearblossom	6	165	39 1	84 447	647,000,000
California Aqueduct (branches)					
Oso	8	70	88 6	69,975	446,000,000
Las Perillas	6	17	12 7	3,021	20,000,000
Badger Hill	6	46	12 7	7,833	56,000,000
Devil's Den	4	125	3.6	5,968	51,000,000
Sawtooth	4	101	3.6	4,849	41,000,000
Polonio	4	247	3 6	11,936	101,000,000
Peripheral Canal					
Total	9	3	617.3	26,259	
State Share			308 7	13,010	88,000,000
Total, State Share					13,691,000,000

1/ Minimum and maximum total pumping heads

2/ Minimum and maximum static heads.

3/ Includes one spare unit.